

MISSOURI
STREAM
TEAM

VOLUNTEER WATER QUALITY MONITORING
LEVEL 2



Volunteer Water Quality Monitoring Staff

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IF YOU DISCOVER A SERIOUS WATER POLLUTION EVENT OR FISH KILL, PLEASE REPORT IMMEDIATELY TO:

MISSOURI DEPARTMENT OF NATURAL RESOURCES

EMERGENCY RESPONSE UNIT 573-634-2436

mdc.mo.gov/fishkills



Volunteer Water Quality Monitoring Level 2

Table of Contents

Chapter 1: Introduction

<i>VWQM Level 2 Training Introduction</i>	1:1
<i>Quality Control Levels</i>	1:1

Chapter 2: Water Chemistry

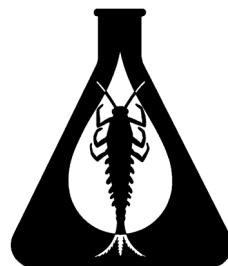
<i>Water Chemistry Introduction</i>	2:1
<i>Sampling Timing</i>	2:2
<i>Watersheds</i>	2:2
<i>Stream Discharge</i>	2:3
<i>Stream Discharge Reminders</i>	2:3
<i>Visual Survey</i>	2:4
<i>Quality Assurance/Quality Control</i>	2:5
<i>Common Sources of Error</i>	2:5
<i>Chemical Waste</i>	2:6
<i>Water Chemistry QC</i>	2:7
<i>Measuring Temperature</i>	2:7
<i>Temperature QC</i>	2:7
<i>Dissolved Oxygen</i>	2:8
<i>DO Troubleshooting</i>	2:8
<i>Measuring DO</i>	2:9
<i>DO QC</i>	2:9
<i>pH</i>	2:10
<i>pH Troubleshooting</i>	2:10
<i>Measuring pH</i>	2:11
<i>pH QC</i>	2:11
<i>Conductivity</i>	2:12
<i>Conductivity Troubleshooting</i>	2:12
<i>Measuring Conductivity</i>	2:13
<i>Conductivity QC</i>	2:13
<i>Nitrate</i>	2:14
<i>Nitrate Troubleshooting</i>	2:14
<i>Measuring Nitrate</i>	2:15
<i>Nitrate QC</i>	2:15

Chapter 3: Aquatic Invertebrate ID

<i>Aquatic Invertebrate ID Introduction</i>	3:1
<i>Factors Affecting Macroinvertebrates</i>	3:2
<i>Stream Microhabitats</i>	3:3
<i>Sampling Reminders</i>	3:2
<i>Specimen Preservation</i>	3:3

<i>Nuisance Species Prevention</i>	3:3
<i>Taxonomic Levels</i>	3:4
<i>Generalized Morphology</i>	3:5
<i>Types of Metamorphosis</i>	3:5
<i>Insects: Mayfly</i>	3:6
<i>Insects: Stonefly</i>	3:8
<i>Insects: Caddisfly</i>	3:10
<i>Insects: Dobsonfly, Fishfly, Alderfly</i>	3:12
<i>Insects: Fly</i>	3:14
<i>Insects: Dragonfly, Damselfly</i>	3:16
<i>Insects: Beetle</i>	3:18
<i>Insects: True Bug</i>	3:20
<i>Insects: Aquatic Caterpillar</i>	3:21
<i>Crustaceans: Crayfish</i>	3:22
<i>Crustaceans: Scud</i>	3:23
<i>Crustaceans: Sowbug</i>	3:24
<i>Worms: Horsehair Worm</i>	3:25
<i>Worms: Aquatic Earthworm, Leach</i>	3:26
<i>Worms: Planarian</i>	3:27
<i>Molluscs: Clam, Mussel</i>	3:28
<i>Molluscs: Snails</i>	3:29

Introduction



The Level 2 workshop is a quality assurance/quality control (QA/QC) training. Quality assurance is the process used to measure and assure the quality of a product. Quality control is the process of ensuring products and services meet product expectations.

By attending this QA/QC workshop, the volunteer can demonstrate that their data meets the level of accuracy and consistency established by the VWQM Program. This data may then be used in a broader range of situations and can withstand most challenges to its validity.

Quality Control Levels

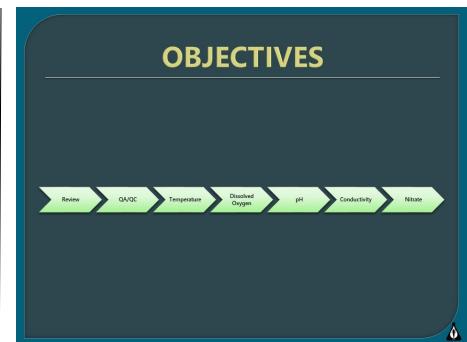
The following are levels of quality control (QC) assigned to data in the Stream Team database:

- **QC Level 1:** Monitor has attended an Introductory and/or Level 1 workshop.
- **QC Level 2:** Monitor has attended a Level 2 workshop¹ and can correctly identify 75% of the invertebrates on an exam, not missing more than two EPT taxa².
- **QC Level 3:** Monitor has been audited in the field by program staff and can correctly identify 90% of the invertebrates at their monitoring site, not missing any EPT taxa.

¹To maintain a QC Level 2 or QC Level 3, monitors must attend a Level 2 or Level 2 Validation training every three years.

²EPT taxa includes the insect orders of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly).

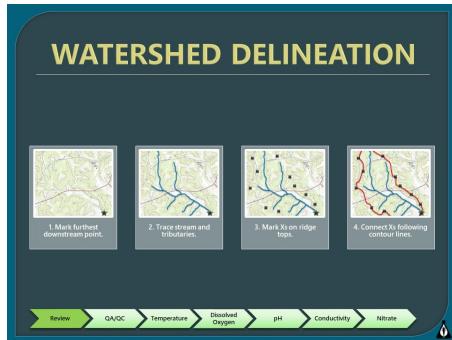
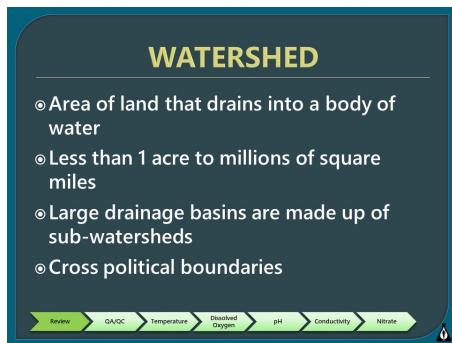
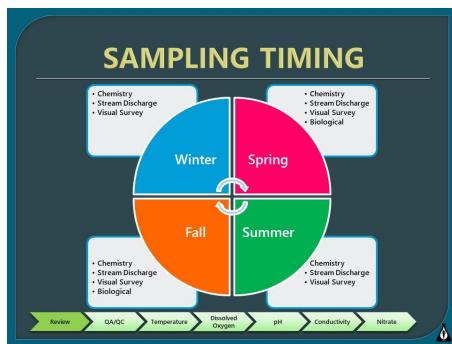
Water Chemistry



Several factors can affect the accuracy of data. During the water chemistry QA/QC portion of the workshop, the reliability of equipment and viability of reagents will be checked. Proper sampling technique will also be assessed.

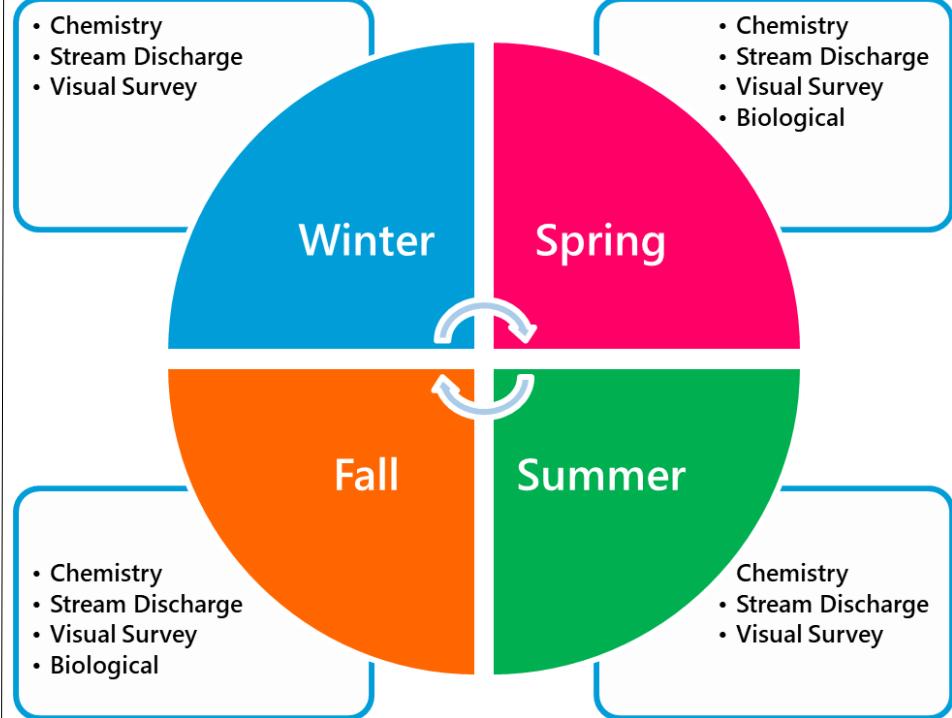
In this section we will cover:

- QC Level 1 review
- QA/QC requirements and chemical disposal
- Temperature QC
- Dissolved oxygen QC
- pH QC
- Conductivity QC
- Nitrate QC



Sampling Timing

The frequency of monitoring is dependent on your goals or project. The VWQM program recommends monitoring at least four times a year, but no more than twice per year for biological monitoring at a given site. The most meaningful data is collected consistently over a long period of time.



Watersheds

A watershed is a topographically defined area that drains into a body of water. Watersheds can range in size from less than an acre to millions of square miles. To delineate the watershed for your monitoring site, follow these steps:

1. Mark your monitoring site on a topographic map, which is the furthest downstream point you will evaluate.
2. Trace the stream and all tributaries upstream from your site.
3. Mark an X on all ridge tops surrounding the stream(s).
4. Connect these Xs while following the contour lines.

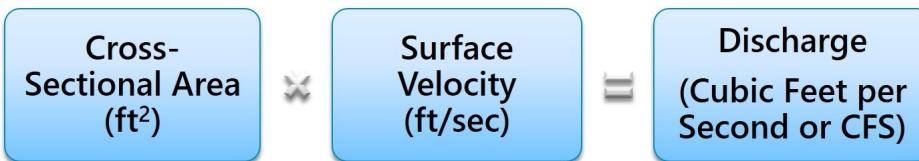


Stream Discharge

Stream discharge is the volume of water flowing past a point in the stream for a given period of time. We measure stream discharge in cubic feet per second (cfs). Stream discharge allows interpretation of other data submitted, such as macroinvertebrate or water chemistry data. For this reason it is important to submit stream discharge data with any other data sheet collected.

To calculate stream discharge:

1. Measure cross-sectional area of point in the stream.
 - a. Measure stream width from flowing edge to flowing edge
 - b. Find average stream depth by measuring stream depth at equal intervals from flowing edge to flowing edge
2. Measure stream velocity by finding the average of at least four float trials.
3. Calculate stream discharge by multiplying cross-sectional area and the corrected stream velocity.



STREAM DISCHARGE

Volume of water flowing past a point in the stream for a given period of time

= Cross Sectional Area (ft²) X Velocity (ft/s)

Review QAQC Temperature Dissolved Oxygen pH Conductivity Nitrate

STREAM DISCHARGE

1a Stream Width
- Flowing edge to flowing edge
- Do not measure dead water or backwards flowing water

1b Stream Depth
- Width < 20
- Measure every 1'
- Width > 20
- Measure every 2'
- No zeros recorded

2. Stream Velocity
- 4 float trials required
- Use mutually buoyant objects

Review QAQC Temperature Dissolved Oxygen pH Conductivity Nitrate

STREAM DISCHARGE

STREAM DISCHARGE DATA SHEET

Please check the box next to the "Site" if this is a new site and please be sure to attach a map. (PLEASE PRINT)

Site is a new site. Stream: _____ County: _____

Site Location: _____ Date: _____ Time: _____ Barometric Pressure: _____ Water Temp: (°C) _____ Stream Flow Number: _____

Water Temp: _____ Stream Flow Number: _____

Permit # _____

If discharge is unreasonable due to obstructions, please indicate: Too low to measure Too high to measure
For opening (SOG) page values greater than zero: 1 SOG = _____ ft

Instructions for Calculation of Stream Discharge (Flow)

Step 1a: Determine stream width. With a series of stakes that is relatively straight, but from large objects such as logs or large boulders, with a noticeable current, and with a depth as uniform as possible. Stretch the tape measure across the width of the stream. The end of the tape measure should be anchored at the opposite end so that it is taut and even with the water surface. Record the width in feet. (e.g. 17 feet equals 17')

Step 1b: Determine stream cross-sectional area. The first step in determining cross-sectional area is to measure and calculate the average stream depth. If the stream is shallow, measure the depth at the center of the stream (e.g. 1.7 feet equals 1.7')

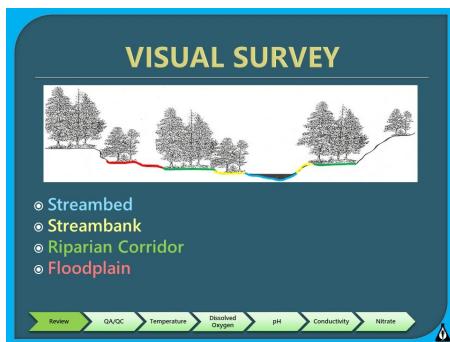
Use data sheet to indicate if flow is too high or low to measure

Review QAQC Temperature Dissolved Oxygen pH Conductivity Nitrate

Stream Discharge Reminders

There are a few items to remember while measuring stream discharge:

- Use the check box on the data sheet to indicate if flow is too high or too low to measure. You do not need to complete the rest of the sheet.
- Only measure stream width from flowing edge to flowing edge. Omit the areas of dead water or where water is flowing backwards.
- Do not report a zero for a stream depth measurement. This indicates there is no water, therefore no flow at that spot.
- At least four float trials are required for calculating average velocity.
- All measurements should be reported in tenths of a foot, not inches.



Visual Survey

Visual Survey is the physical assessment of your monitoring site. Since this is a collection of observations, it can be subjective. The Visual Survey datasheet should be completed by the same monitor at a given site to reduce variation based on opinion. It's most beneficial to collect this data at least twice a year, once with foliage absent and once with foliage present.

Observations in Visual Survey cover the following watershed components:

- **Streambed**—The area where a natural stream runs, or may run, depending on precipitation. This is the area between the streambanks in which substrate is deposited or removed by the energy of moving water. The streambed may be dry during times of the year, especially in the upper stream reaches.
- **Streambank**—The area of land that rises from the streambed and reaches a crest. Such crests are most noticeable when looking at the outside bend of a stream meander. If, and only if, there is no marked change or obvious crest, consider the bank to extend no further than 50 feet away from the streambed.
- **Riparian corridor**—The linear strip of land adjacent to the stream that is within the floodplain. There is variation in the definition of the riparian corridor, particularly related to stream width. VWQM protocol measures riparian corridor from the top of the streambank to 100 feet away from the stream.
- **Floodplain**—The flattened portion of the stream valley susceptible to large floods.

Quality Assurance / Quality Control

Quality assurance (QA) is a set of activities that ensures processes are adequate in order for a system to meet its objectives. An example of this would be sampling protocols that monitors must follow. Quality Control (QC) is a set of activities designed to evaluate the developed products. Verifying the accuracy of a chemical test kit would be a QC measure.

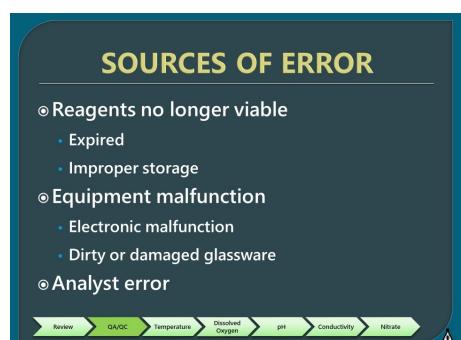
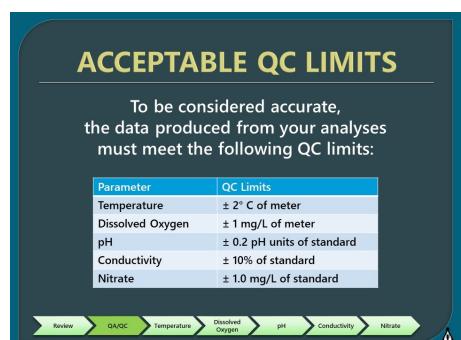
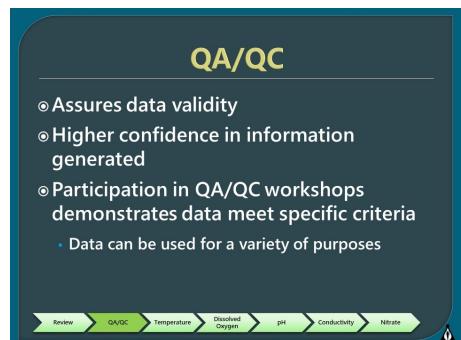
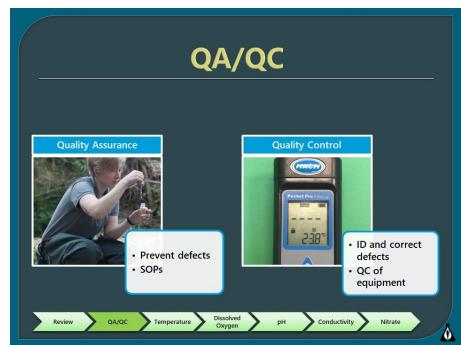
To be considered accurate, the data produced from your analyses must meet the following acceptability limits:

Parameter	QC Limits
Temperature	$\pm 2^\circ \text{C}$ of meter
Dissolved Oxygen	$\pm 1 \text{ mg/L}$ of meter
pH	$\pm 0.2 \text{ pH}$ units of standard
Conductivity	$\pm 10\%$ of standard
Nitrate	$\pm 1.0 \text{ mg/L}$ of standard

Common Sources of Error

If a monitor does not meet the acceptability limits on the analyses, possible sources of errors must be systematically eliminated. The following is a list of possible problems:

1. **Reagents no longer viable**—Analysis should be repeated using viable reagents. Reagents should be stored in a low-moisture, temperature controlled environment.
2. **Equipment malfunction**—Troubleshoot following manufacturer's instructions and replace any damaged equipment.
3. **Analyst error**—An instructor should observe the analyst's technique.





Chemical Waste

The table below gives proper disposal instructions for commonly used VWQM chemicals:

Chemical	Disposal
DO 1 packet	Dispose of packets unopened in trash receptacle
DO 3 powder pillow	Flush down drain with ample cold water
pH 7 buffer solution	Flush down drain with ample cold water
pH 10 buffer solution	Flush down drain with ample cold water
Sodium chloride	Flush down drain with ample cold water
Sodium thiosulfate	Flush down drain with ample cold water
Mixed acid	Flush down drain with ample cold water
DO 2 packet	Return material to Stream Team program
Nitrate reducing reagent	Return material to Stream Team program
Nitrate kit waste	Return material to Stream Team program

Return hazardous waste to the Stream Team program for proper disposal as required by regulations. These may be dropped off at any Stream Team workshop, DNR or MDC regional office, or coordinate with program staff:



Missouri Stream Team
 2901 W Truman Boulevard
 Jefferson City, MO 65109
 800-781-1989
 Streamteam@mdc.mo.gov
 Streamteam@dnr.mo.gov

Water Chemistry QC

Each monitor's chemistry test equipment and reagents will go through QC analysis during this training. The results will be recorded on the provided answer sheet and will be kept on file with program staff for three years until the next QC is required.

Program staff will provide standards and samples to measure. Each chemical parameter is analyzed as a group. Please do not work ahead.

WATER CHEMISTRY QC

© Each chemical parameter will be analyzed as a group -- Please do not work ahead

VWQM LEVEL 2 WORKSHOP		
Name _____	_____	Location _____
Date _____	_____	_____
WATER CHEMISTRY RESULTS		
PARAMETER	RESULT	RANGE
Temperature (°C)	(± 1°C)	(± 10%)
DO (mg/L)	(± 0.8 mg/L)	(± 10%)
Conductivity (µS/cm)	(± 10%)	(± 10%)
pH (1°C)	(± 0.1 pH units)	(± 10%)
Conductivity Standard	(± 0.1 µS/cm)	(± 10%)
pH (1°C) Calibration	(± 0.1 pH units)	(± 10%)
Amonia (NH ₃) (mg/L)	(± 0.1 mg/L)	(± 10%)
pH (1°C) Calibration	(± 0.1 pH units)	(± 10%)
Phosphate (PO ₄) (mg/L)	(± 0.1 mg/L)	(± 10%)
pH Standard	(± 0.1 pH units)	(± 10%)

Review > OA/QC > Temperature > Dissolved Oxygen > pH > Conductivity > Nitrate

TEMPERATURE QC

1. Measure the temperature of the sample water on the table

2. Record result on the answer sheet

PARAMETER	RESULT	RANGE
Temperature (°C)	(± 2°C)	(± 10%)

Review > OA/QC > Temperature > Dissolved Oxygen > pH > Conductivity > Nitrate

Measuring Temperature

VWQM data sheets include air and water temperature, which should be measured in the shade. Measure air temperature first to avoid residual water on the thermometer affecting the temperature reading. When measuring water temperature, read the temperature while the thermometer is still submerged. Always allow several minutes for the thermometer to acclimate, especially in extreme temperatures.

Temperature QC

1. Using your thermometer(s), measure the temperature of the sample water on the table.
2. Record result on the answer sheet.

DISSOLVED OXYGEN (DO)

- Includes concentration of DO (mg/L) and oxygen saturation (%)
- Oxygen saturation is temperature dependent
- Oxygen is more easily dissolved in colder water

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

INFLUENCES ON DO

Natural	Anthropogenic
Temperature	Removal of Vegetation
Flow	Dams
Suspended Solids	Organic Waste
Aquatic Plants	Temperature

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

DO PERCENT SATURATION

General rule for healthy streams

	Ozark Streams > 80% DO Saturation
	Prairie or Lowland Streams > 60% DO Saturation

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

DISSOLVED OXYGEN KIT

- Kit waste may be discarded on ground away from stream
- If floc does not settle, wait 10 minutes and shake bottle again
- Return unused, unopened DO 2 packets to Stream Team program

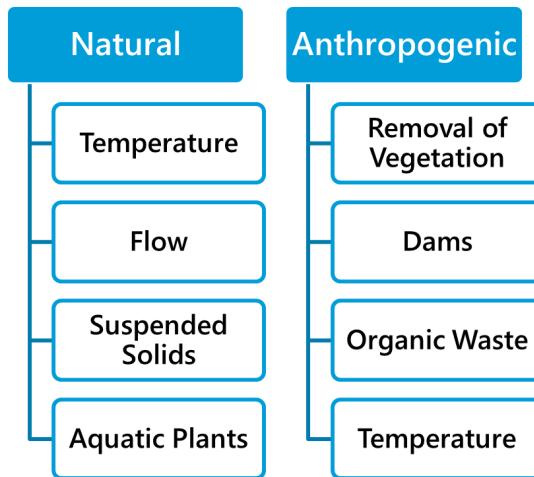
Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

Dissolved Oxygen

Under natural conditions, water generally can hold more than 5 mg/L of dissolved oxygen (DO). To determine what your DO reading means you should calculate percent saturation, which is temperature dependent. Oxygen is more easily dissolved in cold water than in warm water. Slow-moving warm-water prairie streams have will have a much lower saturation point than a fast-moving cool-water Ozark stream.

As a general rule, a healthy Ozark stream has greater than 80% DO saturation, while a healthy prairie or lowland stream will have greater than 60% DO saturation.

There are many influences on stream DO levels. Some of these are natural and some are anthropogenic, or human influenced:

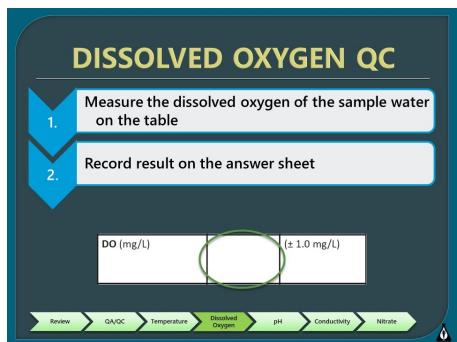


DO Troubleshooting

- Air bubble in sample bottle**—Try one of two methods to collect a sample:
 - Fill the sample bottle slightly into the frosted neck line. Add the DO 1 and 2 reagents, then stopper the bottle. This will result in a little spill-over but will not affect the test.
 - Place the sample bottle in the stream and stopper it while still under water. Remove the sample bottle from the stream and lift the stopper to add DO 1 and 2. A small amount of water that was pooled around the stopper will enter the sample bottle. This should be just enough water to prevent the air bubble when returning the stopper.
- Flocculant slow to settle**—Extremely cold water or high chloride levels will affect how the floc settles. If floc does not settle after 10 minutes, shake the bottle once more and continue with the test.
- Titration drops are small or inconsistent in size**—Hold dropper vertical and give confident, firm squeezes to ensure full drops. Release dropper bulb between drops. Do not allow drops to run down the side of the titration bottle.

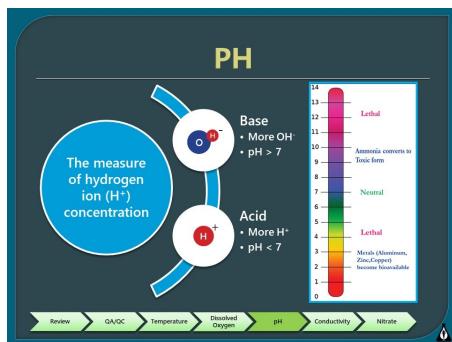
Measuring DO

1. Fill the dissolved oxygen bottle with sample water to the middle of the frosted area by submerging it in the stream.
2. Add the contents of one Dissolved Oxygen Reagent 1 packet and one Dissolved Oxygen Reagent 2 packet.
3. Stopper the bottle without trapping air bubbles.
4. Shake the bottle vigorously to mix.
5. Wait for flocculent to settle to approximately half the bottle volume.
6. Shake the bottle vigorously again.
7. Wait for the flocculent to settle to approximately half the bottle volume.
8. Remove the stopper and add the contents of one Dissolved Oxygen 3 Reagent powder pillow.
9. Stopper the bottle and shake the bottle vigorously (flocculent will dissolve and sample will turn yellow if oxygen is present).
10. Fill the plastic tube to the top with sample from dissolved oxygen bottle.
11. Place the square bottle over the full plastic tube and invert to pour the contents into the square bottle.
12. Add Sodium Thiosulfate Standard Solution one drop at a time to the mixing bottle (making sure to hold the dropper vertical). Count each drop. Swirl to mix after each drop. Add drops until the sample becomes colorless.
13. Record the number of drops used in Step 12. One drop equals one mg/L.



DO QC

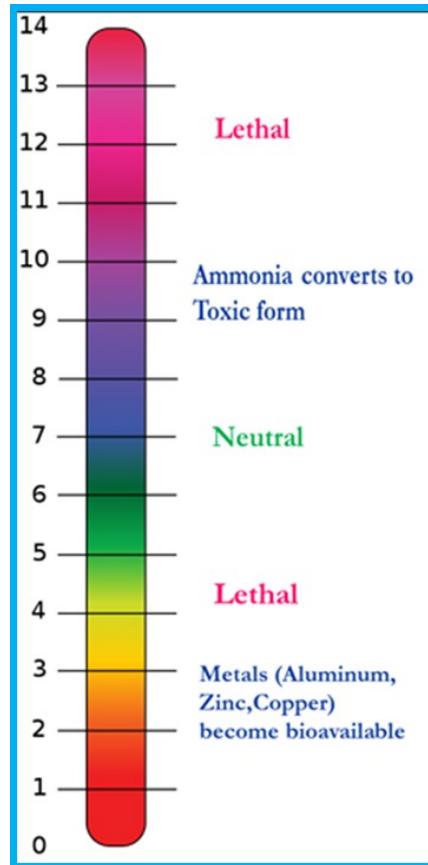
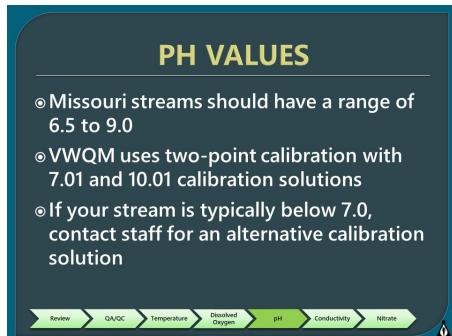
1. Measure the dissolved oxygen of the sample water on the table.
2. Record result on the answer sheet.



pH

The pH levels of most Missouri streams should range from 6.5 to 9.0. Since the average pH of Missouri streams is slightly basic, we use a two-point calibration of 7.0 and 10.01. If typical pH readings for your stream site are below 7.0, please contact VWQM program staff for an alternative calibration solution.

pH levels above 10 and below 6 can be lethal to aquatic life. Lower pH allows sediments to release metals into the water, which can disrupt biological functions or cause deformities in fish.



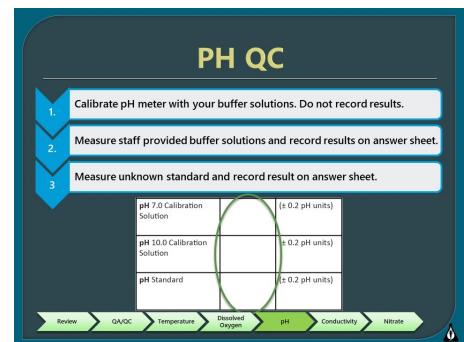
pH Troubleshooting

- White residue buildup on meter probe**—This white residue is potassium chloride. These meters are designed to slowly release potassium chloride to measure pH. To remove a buildup of residue from the meter, simply soak the meter in tap water or buffer solution and swirl. After calibration or measurement, store the meter in the cap with residual tap water or buffer solution. Do not store the pH meter in DI water.
- Air bubble in glass bulb**—The glass bulb is filled with an electrolyte solution. The electrolyte can move and shift during transport or horizontal storage. If an air bubble appears, shake the meter in a downward motion to force the bubble out of the glass bulb. Inspect the bulb for cracks and air bubbles prior to calibration.

Measuring pH

Calibration (within 12 hours prior to monitoring):

1. Set the power to on and remove the cap from the sensor.
2. Push  to go to calibration mode. The auto-recognition standard (7.00) the tester expects will display at the bottom of the screen..
3. Pour the yellow pH 7.00 buffer solution into the cap to the fill line.
4. Put the sensor fully into the cap.
5. When the measurement is stable, push  to save the measurement. The measured value flashes three times.
6. Repeat steps 3-5 with blue pH 10.01 buffer solution.
7. Push and hold  to go to continuous measurement mode. "END" shows on the display.
Note: "ECAL" shows on the display if the calibration was not successful.
8. Rinse the sensor and cap with deionized water and blot dry.



Measurement:

1. Set the power to on.
2. Remove the cap from the sensor.
3. If the lock icon shows on the display, push  to go to continuous measurement mode.
4. Place meter sensor in flowing stream water until reading is stable.
5. The measured value shows on the top line.

pH QC

1. Calibrate your pH meter with your pH 7 and pH 10 buffer solutions. Do not record these results from calibration.
2. Measure the staff provided pH 7 and pH 10 buffer solutions. Record these results on the answer sheet.
3. Measure the unknown standard. Record this result on the answer sheet.

CONDUCTIVITY

- Measures how well an electrical current passes through water
- Dependent on amount of dissolved solids in water
 - Conductivity increases with increased ions (chloride, calcium, bicarbonate, etc.)
- Essential for biological functions

Review > Q/A/QC > Temperature > Dissolved Oxygen > pH > Conductivity > Nitrate

AVERAGE CONDUCTIVITY

St. Francis mountains	30 – 150 $\mu\text{S}/\text{cm}$
Bootheel region	100 – 500 $\mu\text{S}/\text{cm}$
Ozark streams	150 – 500 $\mu\text{S}/\text{cm}$
Northern Missouri	300 – 800 $\mu\text{S}/\text{cm}$
Missouri/Mississippi River	500 – 800 $\mu\text{S}/\text{cm}$
Wastewater effluent	800 – 2000 $\mu\text{S}/\text{cm}$

Review > Q/A/QC > Temperature > Dissolved Oxygen > pH > Conductivity > Nitrate

CONDUCTIVITY METER

- If meter does not calibrate, soak in water with one drop of dish soap
- Calibrate within 12 hours of sampling
- If “----” displays, the sample is over range

Review > Q/A/QC > Temperature > Dissolved Oxygen > pH > Conductivity > Nitrate

Conductivity

Conductivity is the measurement of electrical current that can pass through water. This is dependent on dissolved solids, such as calcium, sodium, iron, and chloride. These dissolved solids form ions, which allow water to conduct electricity. Large amounts of dissolved solids in the stream results in higher conductivity readings.

Conductivity varies greatly from stream to stream. Below is a table of average conductivity readings in Missouri:

Stream location	Average conductivity
St. Francis mountains	30—150 $\mu\text{S}/\text{cm}$
Bootheel region	100—500 $\mu\text{S}/\text{cm}$
Ozark streams	150—500 $\mu\text{S}/\text{cm}$
Northern Missouri	300—800 $\mu\text{S}/\text{cm}$
Missouri/Mississippi River	500—800 $\mu\text{S}/\text{cm}$
Wastewater effluent	800—2000 $\mu\text{S}/\text{cm}$

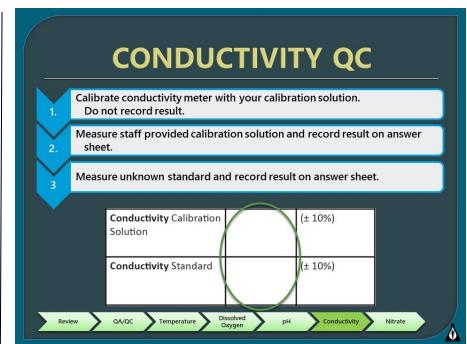
Conductivity Troubleshooting

- Unable to calibrate**—The electrodes probably need cleaned. These black platinum coated silver electrodes have a film coating from the manufacturer. Until the meter is well conditioned, this can interfere with calibration. Soak the meter in tap water with one drop of dish soap for several minutes, occasionally swirling. Do not wipe, rub or use abrasives on the probes.
- Meter displays “----” while measuring conductivity**—Measurement is out of range. Low range conductivity meters can only measure up to 1990 $\mu\text{S}/\text{cm}$. Conductivity measurements exceeding 1990 $\mu\text{S}/\text{cm}$ can be expected in large cities, such as St. Louis, Kansas City, and Springfield, during winter after road salt applications. If an out of range reading occurs and is unexpected for your stream site, contact VWQM program staff to report the high conductivity reading.

Measuring Conductivity

Calibration (within 12 hours prior to monitoring):

1. Set the power to on and remove the cap from the sensor.
2. Push  to go to calibration mode. The auto-recognition standard (1413 or 147 $\mu\text{S}/\text{cm}$) the tester expects will display at the bottom of the screen.
3. Pour the 1413 $\mu\text{S}/\text{cm}$ calibration standard shown into the cap to the fill line.
4. Put the sensor fully into the cap.
5. When the measurement is stable, push  to save the calibration and go to continuous measurement mode. The measured value will flash 3 times and then stop. Then, "END" shows on the display.
6. Rinse the sensor and cap with deionized water and blot dry.



Measurement:

1. Set the power to on.
2. Remove the cap from the sensor.
3. If the lock icon shows on the display, push  to go to continuous measurement mode.
4. Place meter sensor in flowing stream water until reading is stable.
5. The measured value shows on the top line.

Conductivity QC

1. Calibrate your conductivity meter with your calibration solution. Do not record this result from calibration.
2. Measure the staff provided calibration solution. Record this result on the answer sheet.
3. Measure the unknown standard. Record this result on the answer sheet.

NITRATE

- Nitrogen measured as nitrate-nitrogen
- Occurs naturally and required by all organisms
- Excessive amounts overstimulates plant and algae growth

Review G/A/OC Temperature Dissolved Oxygen pH Conductivity Nitrate

NITRATE TEST KIT

-  Do not perform this test if pregnant
-  Always wear gloves and safety goggles
-  Containerize waste in a cubitainer

Review G/A/OC Temperature Dissolved Oxygen pH Conductivity Nitrate

Nitrate

VWQM measures nitrate as nitrogen (NO₃-N). Nitrate levels are dependent on season, organic breakdown, and organic loading. Seasonally, nitrates are higher in the fall due to the organic breakdown of leaves and algae. Septic tanks, wastewater treatment plants, storm drains, feedlots, crop fields, and fertilized lawns can cause elevated nitrate levels. Average nitrate levels in Missouri range from less than 0.25 mg/L to 2.0 mg/L.

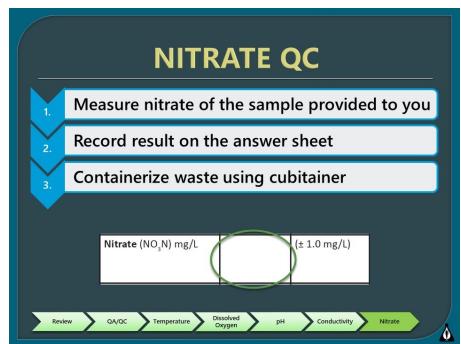


Nitrate Troubleshooting

- **The solution looks yellow after completing the test** — Nitrate tablet #2 is sensitive to sunlight. Keep the test in the foil sleeve from the time tablet #2 is added until the test is complete. Exposing the test tube to sunlight will result in a yellow solution. A yellow solution may also be observed if nitrate is very low, despite not being exposed to sunlight. If you know your test tube was not exposed to sunlight during while running the test and you got a yellow solution, record your value as < 1 mg/L. If you think you may have exposed it to sunlight, rerun the test using the foil sleeve.
- **The solution looks stratified or cloudy after completing the test** — The tablets may not have dissolved. Be sure to shake the test tube vigorously with tablet #1 and tablet #2.
- **The reading is between two values on the colorimeter** — Record the nitrate reading as a range on the data sheet. For example, if the nitrate reading looks to be between 6 and 8 on the colorimeter, record this as, ">6, <8."

Measuring Nitrate

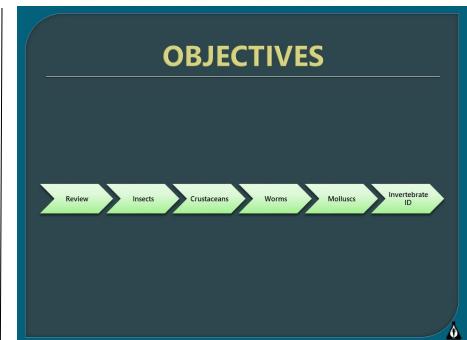
1. Rinse the sample bottle three times with stream water.
2. Fill sample bottle with sample water.
3. Fill one test tube to the 5.0 mL line with water from the sample bottle.
4. Add one Nitrate #1 Tablet.
5. Cap and mix until the tablet disintegrates.
6. Place the test tube in foil protective sleeve.
7. Add one Nitrate #2 Tablet.
8. Cap the test tube and mix for (2) minutes to disintegrate the tablet.
9. Set a timer and wait (5) minutes
10. Remove the test tube from the foil protective sleeve
11. Insert the test tube into the Octa-Slide 2 Viewer (color comparator).
12. Hold the Viewer so that non-direct light enters through the back.
13. Match the sample color to a color on the Viewer.
14. Record the result on the data form as: NO₃-N mg/L.
15. Record a range or number on the data form at NO₃-N mg/L. *Do not use the multiplier on the instructions.*
16. Containerize the liquid waste in a waste container and pour down the drain after returning home.



Nitrate QC

1. Measure the nitrate of the sample provided to you.
2. Record result on the answer sheet.

Aquatic Invertebrate ID



Benthic macroinvertebrates are identified to the taxonomic levels of class, order, or family under Stream Team VWQM protocol. These are the lowest level of identification easily accomplished without magnification. Various keys and identification tools can be used by a monitor until they are familiar with the organisms common in their stream. In this section we will cover:

- Biological sampling review
- Insect identification
- Crustacean identification
- Worm identification
- Mollusc identification
- Invertebrate identification quiz

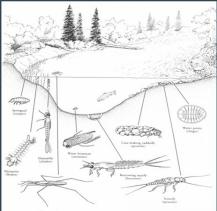
FACTORS AFFECTING MACROINVERTEBRATES

- Dissolved Oxygen
- Toxic Chemicals
 - Acute toxicity (major pollution events)
 - Chronic toxicity (long term exposure at lower levels)
- Silting
 - Increase turbidity
 - Increase embeddedness of substrate
- Habitat Loss
 - Channelization, dams, urban rip-rap, paving of urban streams

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

STREAM MICROHABITATS

- Cobble-rock surface, interstitial spaces
- Fine sediment-silt, sand (burrowing species)
- Vegetation-aquatic plants, woody debris



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

REMINDERS

- Collect samples in an upstream direction
- Do not collect from recently disturbed areas
- Be consistent

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Factors Affecting Macroinvertebrates

Many chemical and physical factors associated with stream quality can affect the structure and function of the macroinvertebrate community.

Loss of abundance and diversity are commonly attributed to:

- ***Low Dissolved Oxygen***
- ***Elevated Toxic Chemicals***
 - * ***Acute toxicity (major pollution events)***
 - * ***Chronic toxicity (long term exposure at lower levels)***
- ***Increased Silting***
- ***Habitat loss due to channelization, dams, and urbanization***
- ***Increased embeddedness of substrate***
- ***Habitat Loss***
- ***Channelization, dams, urban rip-rap, paving of urban streams***

Stream Microhabitats

You are encouraged to sample macroinvertebrates by collecting three net sets from riffle macrohabitat, although rootmat and woody debris macrohabitats can be used if riffles are not present. By collecting each net set from a microhabitat within the riffle you can increase the diversity of your sample.

Microhabitats are created by:

- ***Interstitial spaces between gravel and cobble***
- ***Fine sediment accumulations towards the stream edge***
- ***Fast or slow current***
- ***Shallow or deeper water***
- ***Vegetation***

Sampling Reminders

Regardless of the macrohabitat that you sample, there are several guidelines that you should apply:

- ***Always collect samples in an upstream direction***
- ***Do not sample in areas that you have disturbed***
- ***Be consistent***

Specimen Preservation

Solution	Pros	Cons	Comments
30% Isopropyl	Inexpensive and can be found at most general retailers	Harsh on invertebrates-will make them brittle over time	<ul style="list-style-type: none"> • Buffer with 1-2 drops of glycerin • Sold in 70% and 90% concentrations.
80% Ethyl alcohol (Denatured alcohol)	<ul style="list-style-type: none"> • Best method for long term storage • Less harsh on specimens 	More expensive and difficult to find	<ul style="list-style-type: none"> • Buffer with Tums • Kleen Strip Green Denatured Alcohol • Often near paint supplies • Make sure product is mostly ethyl alcohol, not methanol
Hand Sanitizer	Suspends specimens for viewing	Not recommended for large or soft inverts as it's only 60% alcohol	<ul style="list-style-type: none"> • Gel must be replenished over time as it breaks down into a liquid • Specimen must be euthanized before being placed in gel

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NUISANCE SPECIES PREVENTION				
Technique	Duration	Concentration	Solution	Comments
Vinegar	20 min.	100%	1 gallon of vinegar, no water	Safety glasses and gloves should be worn. Corrosive to metal and toxic to fish.
Chlorine (6% household bleach)	10 min.	3%	4 oz of bleach and 1 gallon of water	Before re-use rinse with water but don't let the solution runoff directly to the stream.
Air Drying	3-5 days	NA	NA	Equipment must dry completely.
Freezing < 32°F	24 hours	NA	NA	Must be below freezing for duration of contact time.
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged.

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TAXONOMIC LEVELS WITH EXAMPLE

Kingdom	• Animalia
Phylum	• Arthropoda
Class	• Insecta
Order	• Ephemeroptera
Family	• Heptageniidae
Genus	• Stenonema
Species	• femoratum



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

VWQM TAXA

Class	• Gilled snail, mussel, aquatic worm, leech, other snail
Order	• Caddisfly, mayfly, stonefly, crayfish, scud, sowbug, other beetle larva
Sub-Order	• Dragonfly, damselfly
Family	• Riffle beetle, water penny, crane fly, alderfly, watersnipe fly, midge, pouch snail
Genus	• Hellgrammite, fishfly

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Taxonomic Levels

Taxonomic levels refer to the organization of macroinvertebrate names that are based on the Linnaeus taxonomic classification system. This naming system is hierarchical, with the broadest grouping starting at “Kingdom” and the narrowest grouping ending at “Species.” The complete system in descending order is: Kingdom, Phylum, Class, Order, Family, Genus, Species. Listed below are the classification groups and common names that the VWQM Program uses for macroinvertebrate identification.

Class

- Gilled snail, mussel, aquatic worm, leech, other snail

Order

- Caddisfly, mayfly, stonefly, crayfish, scud, sowbug, other beetle larva

Sub-Order

- Dragonfly, damselfly

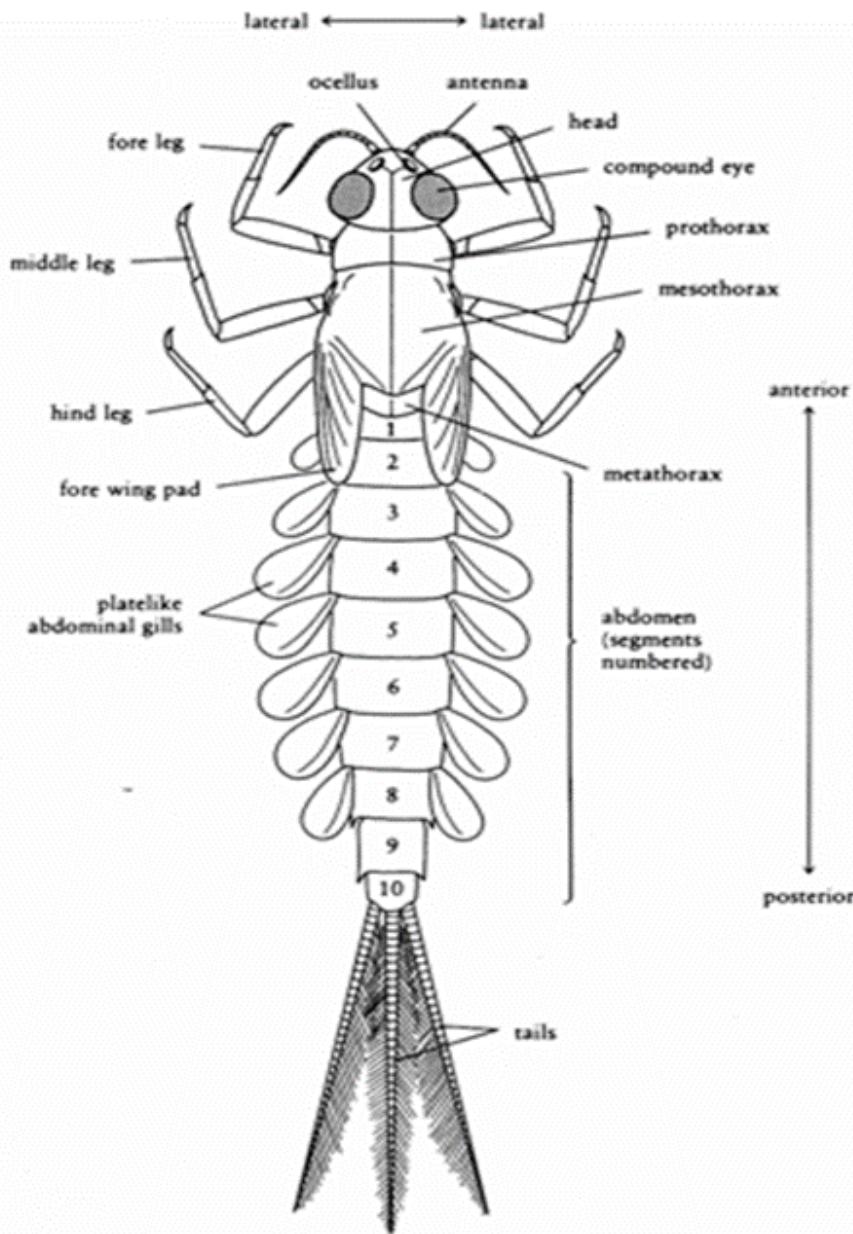
Family

- Riffle beetle, water penny, crane fly, alderfly, watersnipe fly, midge, pouch snail

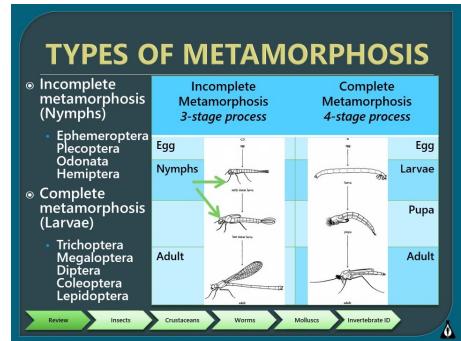
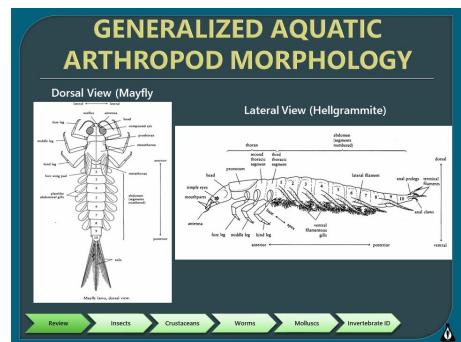
Genus

- Hellgrammite, fishfly

Generalized Morphology



Mayfly larva, dorsal view.



Types of Metamorphosis

The aquatic insects have two distinct life stages, commonly called the adult stage and the immature stage. Between these stages the insects undergo metamorphosis. There are two types of metamorphosis:

- Incomplete (egg, nymph, and adult);
- Complete (egg, larvae, pupae, and adult)

Complete metamorphosis, with the associated pupal stage, allows insects to make more significant body changes from larvae to adult.

MAYFLY (EPEMEROPTERA)

- Three major body regions: head, thorax and abdomen
- Short antennae
- Six legs with one sharp claw on each foot
- One visible pair of wing pads on top of thorax
- Gills on top and sides of abdomen
- Three tails (some have two)
- 1/4"-1" in length (not including tail)



Mayfly adult
MDC photo
Mayfly nymph
MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

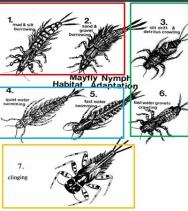
MAYFLY (EPEMEROPTERA)



NABS (www.benthos.org)

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

MAYFLY (EPEMEROPTERA)



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



MDC photo
DNR photo
MDC photo
MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Insects: Mayfly (Emphemeroptera)

A checklist of important mayfly characteristics:

- Three recognizable major body regions (head, thorax and abdomen)
- Short antennae
- Thorax has six jointed legs with one sharp claw on each foot
- One visible pair of wing pads on top of thorax
- Gills attach to sides of abdomen
- Three tails at the end of the abdomen (some have two)
- 1/4"-1" in length (not including tail)

Some useful behavioral characteristics:

- Some are good swimmers
- Others are crawlers
- Mayfly gills may be more visible when the mayfly is at rest in water

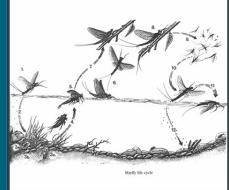


Insects: Mayfly (Ephemeroptera)

Life history details:

- Nymphs live in riffles, sand, or mud burrows for months or years eating mostly algae, detritus, etc.
- Nymphs molt to a terrestrial sub-imago stage, which quickly molts again to mature imago stage
- Emergence of adults may be synchronized
- Adults live for hours or days, mate, and lay eggs on water surface
- In healthy ecosystems, adults of some species can create massive swarms during emergence

MAYFLY (EPHEMEROPTERA)



- Nymphs live in riffles or in sand or mud burrows for months or years eating mostly algae, detritus, etc.
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Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

MAYFLY (EPHEMEROPTERA)



- In healthy ecosystems, adults of some species can create massive swarms during emergence

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



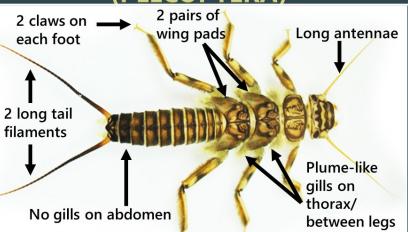
STONEFLY (PLECOPTERA)

- Three major body regions: head, thorax, and abdomen
- Two long bristle-like antennae
- Six legs with two claws on each foot
- Two pairs of large wing pads on thorax
- Might have plume-like gills on thorax between the legs (hairy armpits), abdomen gill-less
- Two bristle-like tails
- 1/8"-1 1/2" long



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

STONEFLY (PLECOPTERA)



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

STONEFLIES (PLECOPTERA)

Diagram of Common STONEFLY families (from PLECOPTERA in Freshwater Benthos):

- HOLOPHORIDAE
- CHOROMORPHIDAE
- PHILOPTERIDAE
- CAMPDIDAE
- PERIANTHIDIUM
- PSEUDANCHODAE
- PHYLLOPODIDAE

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Insects: Stonefly (Plecoptera)

A checklist of important stonefly characteristics:

- Three recognizable major body regions (head, thorax, and abdomen)
- Two long bristle-like antennae
- Thorax has six jointed legs with two claws on each foot
- Two pairs of wing pads on thorax
- Might have plume-like gills on thorax between the legs (hairy armpits), abdomen without gills
- Two bristle-like tails
- 1/8"-1 1/2" long

Some useful behavioral characteristics:

- All are crawlers

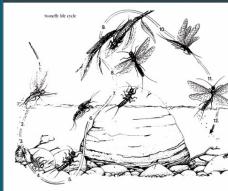


Insects: Stonefly (Plecoptera)

Life history details:

- Nymphs can be common in riffles and are herbivorous, omnivorous or carnivorous, depending on species
- After months or years they crawl out of water and molt into adult
- Adults live a few weeks, mate, and lay eggs on the water

STONEFLY (PLECOPTERA)



- Nymphs usually occupy riffles and are herbivorous, omnivorous or carnivorous, depending on species
- After months or years they crawl out of water and molt into adult
- Adults live a few weeks, mate, and lay eggs on the water

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



CADDISFLY (TRICHOPTERA)

- Three major body regions: head, thorax and abdomen: the head and thorax are much darker and harder than abdomen. Hairy body overall
- Larvae up to 1"
- Three pair of legs
- May have filamentous gills on underside of abdomen.
- The end of abdomen will have a pair of prolegs with hooks at the end
- Larvae have no wing pads and have a very definite grublike or wormlike appearance
- Posterior end of abdomen will usually form a slight crook.

Review Insects Crustaceans Worms Molluscs Invertebrate ID



CADDISFLY (TRICHOPTERA)



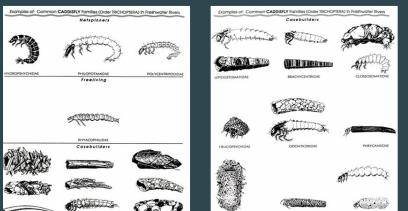
Review Insects Crustaceans Worms Molluscs Invertebrate ID

CADDISFLY (TRICHOPTERA)



Review Insects Crustaceans Worms Molluscs Invertebrate ID

CADDISFLY (TRICHOPTERA)



Review Insects Crustaceans Worms Molluscs Invertebrate ID

Insects: Caddisfly (Trichoptera)

A checklist of important caddisfly characteristics:

- Three major body regions (head, thorax and abdomen)
- The head and thorax are much darker and harder than abdomen
- The abdomen may be hairy
- Thorax has six jointed legs
- May have filamentous gills on underside of abdomen.
- The end of abdomen will have a pair of prolegs with single hooks at the end
- Larvae have no wing pads and have a very definite grublike or wormlike appearance
- Larvae up to 1"

Some useful behavioral characteristics:

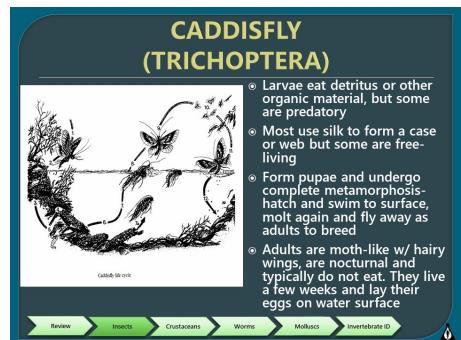
- All are crawlers, but they may try to pull themselves backwards using their abdominal prolegs
- May be free-living, net-spinning, or case makers



Insects: Caddisfly (Trichoptera)

Life history details:

- Larvae eat detritus or other organic material, but some are predatory
- Most use silk to form a case or web but some are free-living
- Form pupae and undergo complete metamorphosis, hatch and swim to surface, molt again, and fly away as adults to breed
- Adults are moth-like with hairy wings, are nocturnal, and typically do not eat. They live a few weeks and lay their eggs on water surface or crawl underwater to lay eggs



DOBSONFLY, FISHFLY, ALDERFLY (MEGALOPTERA)

- Larvae are elongate and slightly flattened
- Head possesses large mandibles
- Head and thorax are harder than abdomen
- Thorax has six legs
- Abdominal segments each have a pair of lateral filaments

 Hellgrammite
MDC photo
Fishfly larvae
DNR photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

DOBSONFLY/HELLGRAMMITE (MEGALOPTERA)

- Very large mandibles capable of a painful pinch
- Has conspicuous gill tufts under lateral filaments
- Very large, up to 4"

 Large gill tufts on abdomen
MDC photo
MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

DOBSONFLY/HELLGRAMMITE (MEGALOPTERA)

Adult male dobsonfly
Photo by Bob Hrabik
Adult female dobsonfly
MDC Photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

FISHFLY (MEGALOPTERA)

- Very similar to hellgrammite
- Has no gill tufts on abdomen
- 2 breathing tubes at end of abdomen

 No gill tufts
2 breathing tubes
Fishfly adult
MDC photo
MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

ALDERFLY (MEGALOPTERA)

- Similar to fishfly and dobsonfly but often smaller
- No gill tufts under filaments
- Abdomen ends in a single long feathery filament
- Rarely collected by VWQM methods

 1 long tail
Alderfly adult
MDC photo
MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Insects: Dobsonfly, Fishfly, Alderfly (Megaloptera)

Dobsonflies, fishflies, and alderflies belong to the Order Megaloptera. However, each can be easily identified and are separately recorded on the VWQM macroinvertebrate datasheet.

A checklist of important dobsonfly, fishfly, and alderfly characteristics:

- Larvae are elongate and slightly flattened
- Head possesses large mandibles
- Head and thorax are harder than abdomen
- Thorax has six jointed legs
- Abdominal segments each have a pair of lateral filaments

A checklist of additional Dobsonfly characteristics:

- Conspicuous gill tufts under lateral filaments
- Prolegs at the end of the abdomen with two claws on the end

A checklist of additional fishfly characteristics:

- Does not have gill tufts under lateral filaments
- Two breathing tubes near the end of abdomen
- Prolegs at end of the abdomen with two claws on the end

A checklist of additional alderfly characteristics:

- Does not have gill tufts under lateral filaments
- Abdomen ends in a single long feathery filament

Insects: Dobsonfly, Fishfly, Alderfly (Megaloptera)

Some useful behavioral characteristics:

Alderfly are widespread in Missouri (see red dots on graphic below) but are rarely collected by VWQM methods. MoDNR data shows that when they are collected : 80% are found in pools; 25% are found on rootmat; 9% are found in riffles; and 4% are found on woody debris.

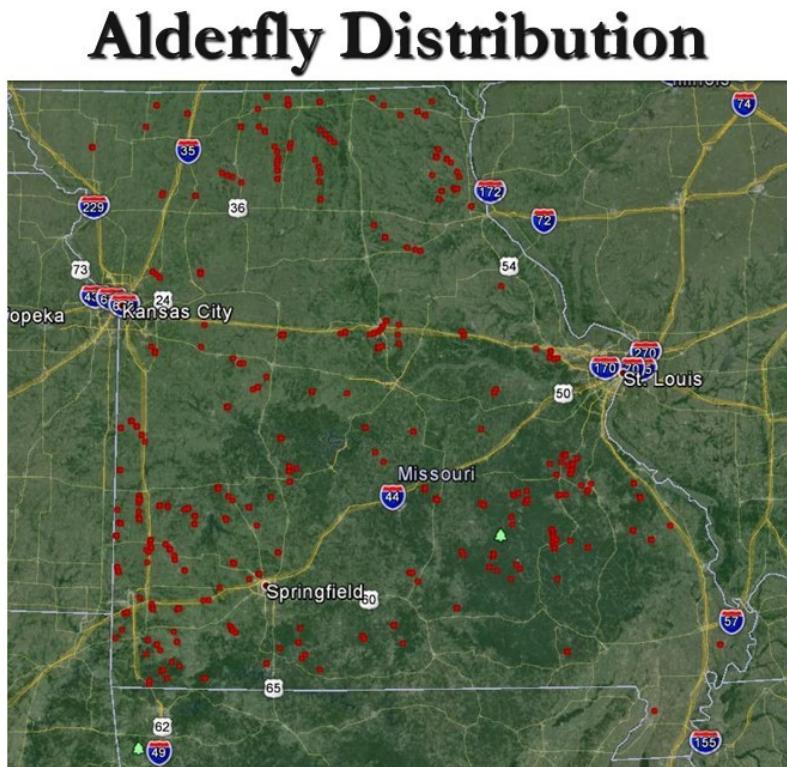
Life history details:

- Larvae are mostly predatory, feeding on other invertebrates or even small fish
- Larvae live in water for as long as 2-3 years
- Hellgrammites are often found in riffles, while fishflies and alderflies can be found in slower water among organic debris or in rootmat
- Larvae crawl out of water to pupate on land
- Adults live days to a week and do not eat. They are often nocturnal and are poor fliers
- Females lay eggs on vegetation overhanging water

DOBSONFLY, FISHFLY, ALDERFLY (MEGALOPTERA)

- Larvae are mostly predatory, feeding on other invertebrates or even small fish
- Larvae live in water for as long as 2-3 years
- Hellgrammites are often found in riffles, while fishflies and alderflies can also be found in slower water among organic debris or silt
 - Larvae crawl out of water to pupate on land
- Adults live days to a week and do not eat.
 - They are often nocturnal and are poor fliers
 - Females lay eggs on vegetation overhanging water

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



**FLY
(DIPTERA)**

- Very diverse group, many with aquatic larvae
- Adult forms are highly variable, but always have only one pair of wings (other insects have two)
- Larvae are usually elongate and maggot-like
 - Head may or may not be well developed and conspicuous
 - Eyes are poorly developed
 - Wing pads are absent

Thrush never possesses three pairs of segmented legs, but prolegs may be present near head or on abdomen

Adult horsefly



MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Insects: Fly (Diptera)

Diptera are a very diverse group; many have aquatic larvae. Fly larvae can be found in almost any aquatic environment, with some, such as midges and mosquitoes, being capable of living in extremely stagnant or polluted water. Most aquatic fly larvae are generalists and feed on detritus or any organic materials, but some are predatory. Adult forms are also highly variable, but always have only one pair of wings (other insects have two).

A checklist of important fly characteristics:

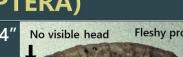
- Larvae are usually elongate and maggot-like
- Head capsule may or may not be well developed and conspicuous
- Eyes are poorly developed
- Wing pads are absent
- Thorax never possesses jointed legs, but fleshy prolegs may be present near head or on abdomen

A checklist of additional cranefly characteristics:

- Larvae can be up to 4" long
- Very soft-bodied
- Abdomen ends in flattened plate, projections, or is bulbous
- No distinct head

**CRANE FLY
(DIPTERA)**

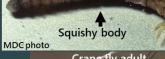
- Larvae can be up to 4"
- Very soft-bodied
- Abdomen ends in flattened plate, projections, or is bulbous
- Larvae very mobile
- Adults don't eat, or drink nectar and have a short lifespan



No visible head Fleshy projections

MDC photo

↑
Squishy body



Crane fly adult

MDC photo

A checklist of additional watersnipe fly characteristics:

- Abdomen ends in 2 horn-like projections
- No distinct head

A checklist of additional midge fly characteristics:

- Prolegs behind head and at end of abdomen
- Most are very small (<1/2")
- Some larvae are red or pinkish (bloodworms); others are green or clear
- Have a hard, distinctive head capsule

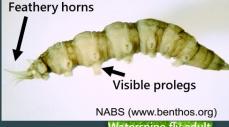
Insects: Fly (Diptera)

A checklist of additional black fly characteristics:

- Larvae small (<1/2")
- Have a distinct head capsule
- Have a proleg behind the head capsule
- Have a distinctive "bowling pin" shape

WATERSNipe FLY (DIPTERA)

- Abdomen ends in 2 horn-like projections
- No distinct head
- Moves like a caterpillar with its prolegs
- Rare in Missouri



NABS (www.benthos.org)
Watersnipe fly adult
Wiki Commons

[Review](#) > [Insects](#) > [Crustaceans](#) > [Worms](#) > [Molluscs](#) > [Invertebrate ID](#)

Some useful behavioral and life history characteristics:

- Although cranefly larvae do not have segmented legs they can be very mobile and "crawl" well
- Watersnipe flies move like a caterpillar with its prolegs
- Watersnipe flies are not widely distributed in Missouri. They are restricted to cool water streams in the Ozarks (see red dots on the distribution map below)
- Midge fly larvae slowly crawl and when suspended in water will generally "flip" and "twitch" in jerky motions
- Black fly larvae stick to surfaces with the end of their abdomen

HORSE/DEER FLY (DIPTERA)

- Larvae similar to watersnipe fly
 - lacks horns and has prolegs or creeping welts that circle the body
- Larvae very mobile
- Up to 1 1/2" long
- Larvae are predatory or eat detritus.
- Adults feed on nectar/pollen and females also feed on blood to produce eggs



MDC photo
Horsefly adult
MDC photo

[Review](#) > [Insects](#) > [Crustaceans](#) > [Worms](#) > [Molluscs](#) > [Invertebrate ID](#)

MIDGE (DIPTERA)

- No jointed legs, only prolegs behind head and at end of abdomen
- Most are very small (<1/2")
- Some larvae are red or pinkish (bloodworms)
- J-shaped when preserved
- Adults often swarm and rarely eat



NABS (www.benthos.org)
Adult Midge
MDC photo

[Review](#) > [Insects](#) > [Crustaceans](#) > [Worms](#) > [Molluscs](#) > [Invertebrate ID](#)

BLACK FLY (DIPTERA)

- Larvae small (<1/2")
- Stick to surfaces with their abdomen
- Filter feed using feathery mouthparts
- Pupae stick to surfaces too and have thread-like tassels
- Adult females feed on blood to produce eggs



Steve Marshall
Black Fly pupae
MDC photo
Black Fly adult
NABS photo

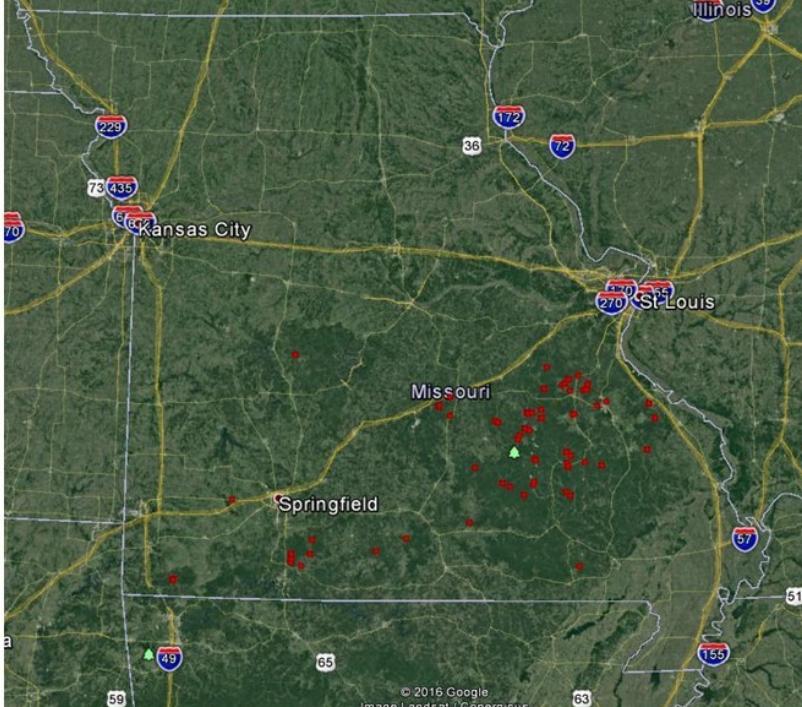
[Review](#) > [Insects](#) > [Crustaceans](#) > [Worms](#) > [Molluscs](#) > [Invertebrate ID](#)

FLIES (DIPTERA)

- Most aquatic fly larvae are generalists and feed on detritus or any organic material. They are also often very low on the aquatic food chain
- Fly larvae can be found in almost any aquatic environment, with some, such as midges and mosquitoes, being capable of living in extremely stagnant or polluted water
- Pupae highly variable; may be free-living or sedentary and have gills or breathe air
- Adults either don't eat, feed on nectar or other plant juices, drink blood, or are predatory

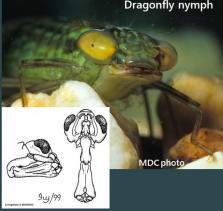
[Review](#) > [Insects](#) > [Crustaceans](#) > [Worms](#) > [Molluscs](#) > [Invertebrate ID](#)

Watersnipe Fly Distribution



DRAGONFLY AND DAMSELFLY (ODONATA)

- Six long legs
- Two very large compound eyes
- A extendable labium (mouth) that is hinged and designed to grab prey. It is folded under the head and thorax
- No gills, plumes, or hair-like projections on the abdomen or thorax
- Length ranges from $\frac{1}{4}$ " - 2"

 Dragonfly nymph

 MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

DRAGONFLY (ODONATA)

- No tail or outer surface gills
- Wide, oval to round abdomen
- Nymphs can jet propel by expelling water from their rectum

 Wide abdomen
No tail
MDC photo

 Dragonfly adult
MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Insects: Dragonfly, Damselfly (Odonata)

Dragonfly and damselfly nymphs are aggressive predators, using their labium to catch prey as large as amphibians and even small fish.

A checklist of important dragonfly and damselfly characteristics:

- Three major body regions (head, thorax and abdomen)
- Thorax has six jointed legs
- Two large compound eyes
- An extendable labium (lower lip) that is hinged and designed to grab prey. It is folded under the head and thorax
- No gills, plumes, or hair-like projections on the abdomen or thorax
- Length ranges from $\frac{1}{4}$ "-2"

A checklist of additional dragonfly characteristics:

- No tail or outer surface gills
- Wide, oval to round abdomen

A checklist of additional damselfly characteristics:

- Three large, paddle-like tails (actually tracheal gills)
- Abdomen long and slender and thorax very short and wider with very tightly folded, high, dorsal wing cases



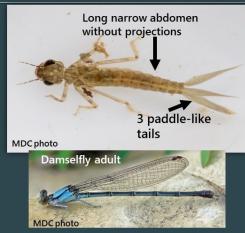
Insects: Dragonfly, Damselfly (Odonata)

Some useful dragonfly and damselfly behavioral characteristics:

- Dragonfly nymphs can jet propel by expelling water from their rectum
- Damselfly nymphs can swim by undulating their bodies

DAMSELFLY (ODONATA)

- Three large, paddle-like tails that are actually tracheal gills
- Abdomen long and slender and thorax very short and wider with very tightly folded, high, dorsal wing cases
- Nymphs can swim by undulating their bodies



MDC photo

Damselfly adult

MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Life history details for dragonfly and damselfly:

- Nymphs commonly occur in still water or stream edges clinging to aquatic vegetation or rootmat, but some nymphs are bottom-dwelling
- Nymphs can stay in water for 1-2 years, depending on species and environment
- Nymphs crawl out of water for their final molt to become adults
- Adults eat flying insects (midges, mosquitoes, etc.)
- Mating pairs fly in tandem
- Females lay eggs in water



MDC photo

MDC photo

MDC photo

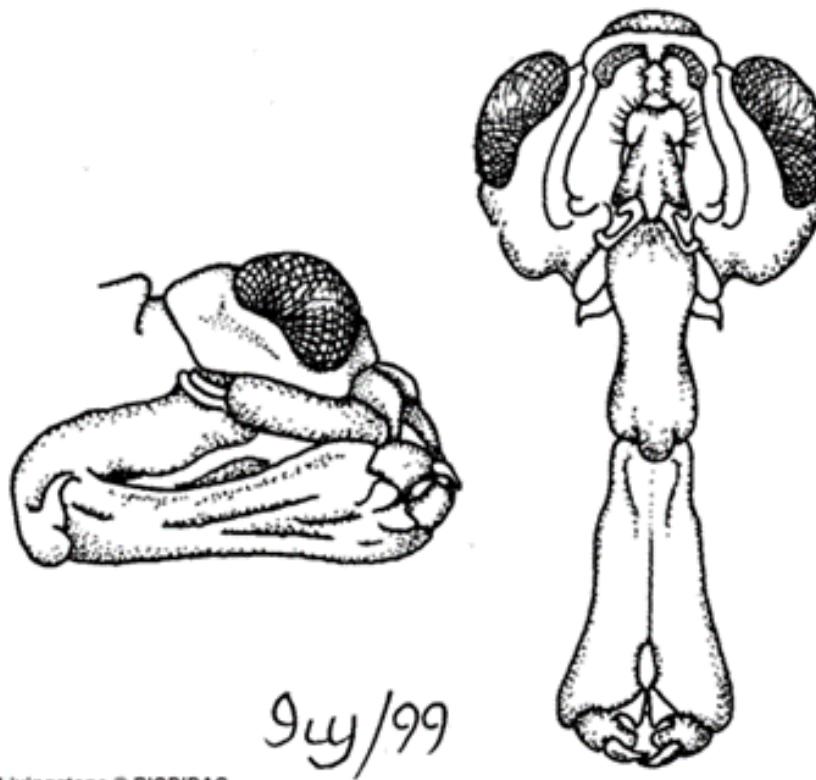
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Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

DRAGONFLY AND DAMSELFLY (ODONATA)

- Nymphs are aggressive predators, using their labium to catch prey as large as amphibians & small fish
- Damselfly and many dragonfly nymphs occur in still water or stream edges clinging to aquatic vegetation or root mats, but some dragonfly nymphs are bottom-dwelling
 - Nymphs can stay in water for years depending on species and environment
 - Nymphs crawl out of water for their final molt to become adults
- Adults eat flying insects (midges, mosquitoes, etc.)
 - mating pairs fly in tandem
 - Females lay eggs in water

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



BEETLE (COLEOPTERA)

- Most diverse group of animals, but most are fully terrestrial
- Adults are hard-bodied, oval to elongate
 - Head possesses chewing mouthparts, well-developed eyes, and variably shaped antennae.
 - Fore wings are modified into hardened covers (elytra) over the abdomen and the hind wings
- Larvae are variously shaped and measure $\frac{1}{4}$ "-1" at maturity
 - Head is usually distinct in larvae and possesses chewing mouthparts
 - Wing pads are absent on larvae.
 - Thorax has 6 well-developed legs
 - Abdomen may possess lateral and/or terminal filaments, tail-like structures, gills



Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

RIFFLE BEETLE (COLEOPTERA)

- Very small, $\frac{3}{8}$ "
- Larvae are grub-like but covered with hard plates over entire body
- Adults are dark colored and slow crawling
- Both larvae and adult are aquatic and feed on algae/detritus







Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

WATER PENNY (COLEOPTERA)

- Very dorsally flattened and saucer-shaped
- Segmented body with legs underneath
- Moves slowly, clinging to rock surfaces in riffles to feed on algae
- Adults are terrestrial





Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Insects: Beetle (Coleoptera)

Beetles are the most diverse group of animals, but most are fully terrestrial.

A checklist of important beetle characteristics:

Adults

- Hard-bodied, oval to elongate
- Head possesses chewing mouthparts, well-developed eyes, and variably shaped antennae.
- Fore wings are modified into hardened covers (elytra) over the abdomen and the hind wings

Larvae

- Variously shaped and measure $\frac{1}{4}$ "-1" at maturity
- Head is usually distinct in larvae and possesses chewing mouthparts
- Wing pads are absent on larvae.
- Thorax has six jointed legs
- Abdomen may possess lateral and/or terminal filaments, tail-like structures, gills

A checklist of additional riffle beetle characteristics:

- Very small, $\sim\frac{3}{8}$ "
- Larvae are covered with hard plates over entire body
- Adults are dark colored with fairly long legs

A checklist of additional water penny characteristics:

- Very dorsally flattened and saucer-shaped
- May have gills on the abdomen

A checklist of additional Other Beetle characteristics:

- Larvae are variously shaped (some have lateral projections)
- Adults are generally oval and convex

Insects: Beetle (Coleoptera)

Some useful beetle behavioral characteristics:

- Adult riffle beetles are slow crawlers
- Water penny larvae crawl slowly, clinging to rock surfaces in riffles

Life history details for beetles:

- Both larvae and adult riffle beetles are aquatic and feed on algae/detritus
- Water penny larvae scrape algae off rocks
- Water penny adults are terrestrial
- Species are highly variable but aquatic larvae tend to be benthic
- Diet variable; may feed on algae/detritus (riffle beetles and water penny larvae), or may be aggressive predators of other insects and small fish (predacious diving beetles and whirligig beetles)
- All go through a pupal stage to become adults
- Adults of many aquatic beetle species trap air bubbles to their abdomen via specialized structures on their exoskeleton to breathe under water for short periods
- The adults of aquatic beetles are generally capable of flight and many are powerful swimmers
- Some species prefer riffles but many others prefer still water habitats like pools, ponds, and stream edges



OTHER BEETLES (COLEOPTERA)

- There are many other aquatic beetles
- Larvae are variously shaped
- Adults are generally oval and convex
- Adults may swim underwater or on the surface, or crawl on the bottom
- Herbivorous, omnivorous, or carnivorous depending upon species and life stage

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



BEETLE (COLEOPTERA)

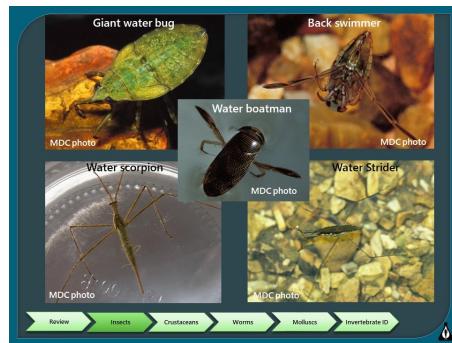
- Species are highly variable but aquatic larvae tend to be benthic
- Diet variable; may feed on algae/detritus (riffle beetles and water penny larvae), or may be aggressive predators of other insects and small fish (predacious diving beetles and whirligig beetles)
- All go through a pupal stage to become adults
- Adults of many aquatic beetle species trap air bubbles to their abdomen via specialized structures on their exoskeleton to breathe under water for short periods
- The adults of aquatic beetles are generally capable of flight and many are powerful swimmers too
- Some species prefer riffles but many others prefer still water habitats like pools, ponds, and stream edges

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

TRUE BUG (HEMIPTERA)

- Very diverse, but all have a straw-like beak (proboscis), 6 legs, and large eyes. Many have raptorial forearms and wings as adults
- Nymphs closely resemble adults
- Aquatic species are generally predatory and inject venom and digestive enzymes into their prey and drink its fluids through their beak
- May be at or just below water surface or clinging to aquatic vegetation in still or shallow water
- Usually air-breathing, some breathe out of tubes on their abdomen like a snorkel

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Insects: True Bug (Hemiptera)

A checklist of important true bug characteristics:

- Very diverse, but all have a straw-like beak (proboscis)
- Thorax has six jointed legs
- Have large eyes
- Many have raptorial forearms
- Most adults are winged

Some useful true bug behavioral characteristics:

- Some are very good swimmers
- Many are slow crawlers

Life history details for true bugs:

- Nymphs closely resemble adults
- Aquatic species are generally predatory and inject venom and digestive enzymes into their prey and drink its fluids through their beak
- May be at or just below water surface or clinging to aquatic vegetation in still or shallow water
- Usually air-breathing, some breathe out of tubes on their abdomen like a snorkel



Insects: Aquatic Caterpillar (Lepidoptera)

A few species of moths have aquatic larvae

A checklist of important aquatic caterpillar characteristics:

- Larvae resemble terrestrial caterpillars
- Long body
- Chewing mandibles
- Thorax has six short jointed legs,
- Have several abdominal prolegs
- May have filamentous gills covering body

AQUATIC CATERPILLAR (LEPIDOPTERA)

- A few species of moths have aquatic larvae
- Larvae resemble terrestrial caterpillars; long body, chewing mandibles, 6 developed legs, and several abdominal prolegs
- May have filamentous gills covering body
- Are found around aquatic vegetation
- Adults are terrestrial and resemble a typical moth

Some useful aquatic caterpillars behavioral characteristics:

- Are found around aquatic vegetation

Life history details for aquatic caterpillars:

- Adults are terrestrial and resemble a typical moth



**CRAYFISH
(DECAPODA)**

- Easily recognized (looks like small lobster)
- Can be found in most aquatic environments
 - Some hide under boulders or cobble, or dig burrows in mud, silt, or gravel
- Will eat virtually anything from algae, detritus, and vegetation to live invertebrates, fish, and carrion
- Very diverse in Mo-35 species including 7 endemic species
- The Ozarks have some of the highest densities of crayfish on Earth
 - Crayfish play a very important role in stream ecosystems, linking benthic food webs to larger animals such as bass, otters, raccoons, herons, hellbenders, etc.

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



Northern crayfish



MDC photo

Painted devil crayfish



MDC photo

Freckled crayfish



MDC photo

Belted crayfish



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Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Crustaceans: Crayfish (Decapoda)

A checklist of important crayfish characteristics:

- Thorax has eight jointed walking legs
- Thorax has two modified legs with claws
- Easily recognized (looks like small lobster)

Some useful crayfish behavioral characteristics:

- Can be found in most aquatic environments, usually hide under boulders or cobble, or dig burrows in mud, silt, or gravel

Life history details for crayfish:

- Will eat virtually anything from algae, detritus, and vegetation to live invertebrates, fish, and carrion
- Very diverse in Missouri (35 species including 7 endemic species)
- The Ozarks have some of the highest densities of crayfish on Earth
- Crayfish play a very important role in stream ecosystems, linking benthic food webs to larger animals such as bass, otters, raccoons, herons, hellbenders, etc.



Crustaceans: Scud (Amphipoda)

A checklist of important scud characteristics:

- Thorax has seven pairs of jointed legs
- Abdomen has six pairs of appendages
- $\frac{1}{4}'' - \frac{3}{4}''$ in length
- Pale in color
- Shrimp-like and laterally compressed

**SCUD
(AMPHIPODA)**

- 7 pairs of legs and 6 pairs of abdominal appendages
- $\frac{1}{4}'' - \frac{3}{4}''$ in length
- C-shaped and pale in color
- Shrimp-like and laterally compressed
- Swim quickly on their side
- Eats detritus and can be found in many aquatic habitats (streams, ponds, caves etc.)
- Can be very abundant in some streams



MDC photo



MDC photo

[Review](#) > [Insects](#) > [Crustaceans](#) > [Worms](#) > [Molluscs](#) > [Invertebrate ID](#)

Some useful scud behavioral characteristics:

- Very good swimmers

Life history details for scuds:

- Eat detritus and can be found in many aquatic habitats (streams, ponds, caves, etc.)
- Can be very abundant in some streams



**SOWBUG
(ISOPODA)**

- Very similar to pill bugs (rollie pollies)
- 7 pairs of legs
- Dorsally flattened
- $\frac{1}{4}''$ - $\frac{3}{4}''$ in length
- Generally found hiding between rocks and under debris in streams, cave pools, etc.
- Feeds on organic debris such as dead leaves
- Can be very abundant in some streams



MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Crustaceans: Sowbug (Isopoda)

A checklist of important sowbug characteristics:

- Very similar to terrestrial pill bugs (roly poly)
- Seven pairs of jointed legs
- Dorsally flattened
- $\frac{1}{4}''$ - $\frac{3}{4}''$ in length

Some useful sowbug behavioral characteristics:

- Crawlers

Life history details for sowbugs:

- Generally found hiding between rocks and under debris in streams, cave pools, etc.
- Feed on organic debris such as dead leaves
- Can be very abundant in some streams



Worms: Horsehair Worm (Nematomorpha)

A checklist of important horsehair worm characteristics:

- Very long and thin
- Can grow up to 20-40"
- Unsegmented
- Featureless
- Does not break apart easily

HORSEHAIR WORM (NEMATOMORPHA)

- Can grow up to 20-40" and is very thin, unsegmented, and featureless
- Often writhes in knots
- Larvae are parasites within aquatic and terrestrial arthropods and when mature erupt from their host's rectum upon entering water
- Adults are free-living and die after reproducing
- Some larvae chemically alter their host's brain, causing it to seek out water when it is ready to emerge



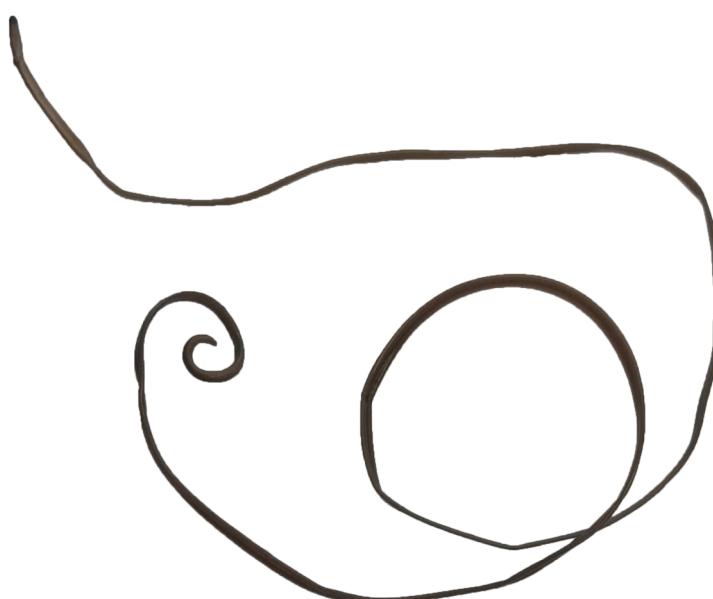
Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Some useful horsehair worm behavioral characteristics:

- Often writhes in knots
- If still, can look like a long light-colored root

Life history details for horsehair worms:

- Larvae are parasites within aquatic and terrestrial arthropods and when mature erupt from their host's rectum upon entering water
- Some larvae chemically alter their host's brain, causing it to seek out water when it is ready to emerge
- Adults are free-living and die after reproducing



**AQUATIC EARTHWORM
(ANNELIDA)**

- Resembles a typical segmented earthworm
- Pale pink in color
- Found in most aquatic habitats
 - Burrows in substrate or under debris
- Feeds on any organic material
- Hermaphroditic

 MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

**LEECH
(ANNELIDA)**

- Segmented and flattened
- Can be several inches long
- Often black or brown but some are spotted or striped
- Possess a suction disc on at least one end
- Very flexible and mobile
- Can be found in most aquatic habitats
- Some are predatory, others specialize in sucking blood from specific hosts (mammals, fish, snails, etc)
- Hermaphroditic

 MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Worms: Aquatic Earthworm, Leech (Annelida)

A checklist of important aquatic earthworm characteristics:

- Resembles a small earthworm
- Pale pink in color
- Segmented
- Breaks apart easily, fragile

Some useful aquatic earthworm behavioral characteristics:

- Often writhes in knots
- Will readily crawl if left alone

A checklist of important leech characteristics:

- Segmented and flattened
- Can be several inches long
- Often black or brown but some are spotted or striped
- Possess a suction disc on at least one end
- Tough skin, not fragile

Some useful leech behavioral characteristics:

- Very flexible and mobile
- Moves by stretching forward with front and then bringing both ends together

Life history details for aquatic earthworms and leeches:

- Both can be found in most aquatic habitats
- Both are hermaphroditic
- Aquatic earthworms burrow in substrate or under debris and feeds on any organic material
- Some leeches engulf prey, others specialize in sucking blood from specific hosts (mammals, fish, snails, etc.)

Worms: Planarian (Platyhelminthes)

A checklist of important planarian characteristics:

- Flat
- $\frac{1}{4}$ " – 1" long
- Arrowhead shaped head with 2 eye spots
- Mostly black or brown

**PLANARIAN
(PLATYHELMINTHES)**

- A flat worm
- $\frac{1}{4}$ " – 1" long
- Tapered head with 2 eye spots
- Can be found in most aquatic habitats
- Feeds on detritus or small invertebrates
- Hermaphroditic
- Can regenerate from cut pieces



MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Some useful planarian behavioral characteristics:

- Will compress into flattened disc when disturbed
- Move by gliding

Life history details for planarians:

- Can be found in most aquatic habitats
- Feed on detritus or small invertebrates
- Hermaphroditic
- Can regenerate from pieces



**CLAM AND MUSSEL
(BIVALVIA)**

- Easily recognized by their 2-piece shell
- Found in rivers, streams, or ponds depending on species
 - Usually partly buried in substrate
- Filter feeders
- Their young parasitize fish to incubate
- Freshwater mussels are most diverse in the U.S.
 - 69 species found in Mo-about half are of conservation concern due to siltation, pollution, and dams

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



Molluscs: Clam, Mussel (Bivalvia)

A checklist of important clam and mussel characteristics:

- Clams and Mussels have a 2-piece shell

Some useful clam and mussel behavioral characteristics:

- Usually partly buried in substrate

Life history details for clams and mussels:

- Found in rivers, streams, or ponds depending on species
- Filter feeders
- Their young parasitize fish to develop
- Freshwater mussels are most diverse in the U.S.
- 69 species found in Missouri-about half are of conservation concern due to threats from siltation, pollution, and dams



Molluscs: Snails (Gastropoda)

A checklist of important snail characteristics:

- Snails have a single shell
- Gilled snails have an operculum and their shell opens on the right side
- Pouch snails do not have an operculum and their shell opens on the left side

SNAILS (GASTROPODA)



- Gilled snails have an operculum and their shell opens on the right side, in contrast to pouch snails
- Gilled snails extract oxygen from the water whereas pouch and ramshorn snails possess a lung-like organ and many surface for air
- Gilled snails are usually found in streams, while other aquatic snails can be found in most water bodies
- Eat algae and carrion with their scraping mouthparts
- Pouch and ramshorn snails are hermaphroditic, unlike gilled snails

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Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Some useful snail behavioral characteristics:

- Will crawl if undisturbed

Life history details for snails:

- Gilled snails extract oxygen from the water whereas pouch and ramshorn snails possess a lung-like organ and many surface for air
- Gilled snails are usually found in streams, while other aquatic snails can be found in most water bodies
- Eat algae and carrion with their scraping mouthparts
- Pouch and ramshorn snails are hermaphroditic, unlike gilled snails



Invertebrate Identification

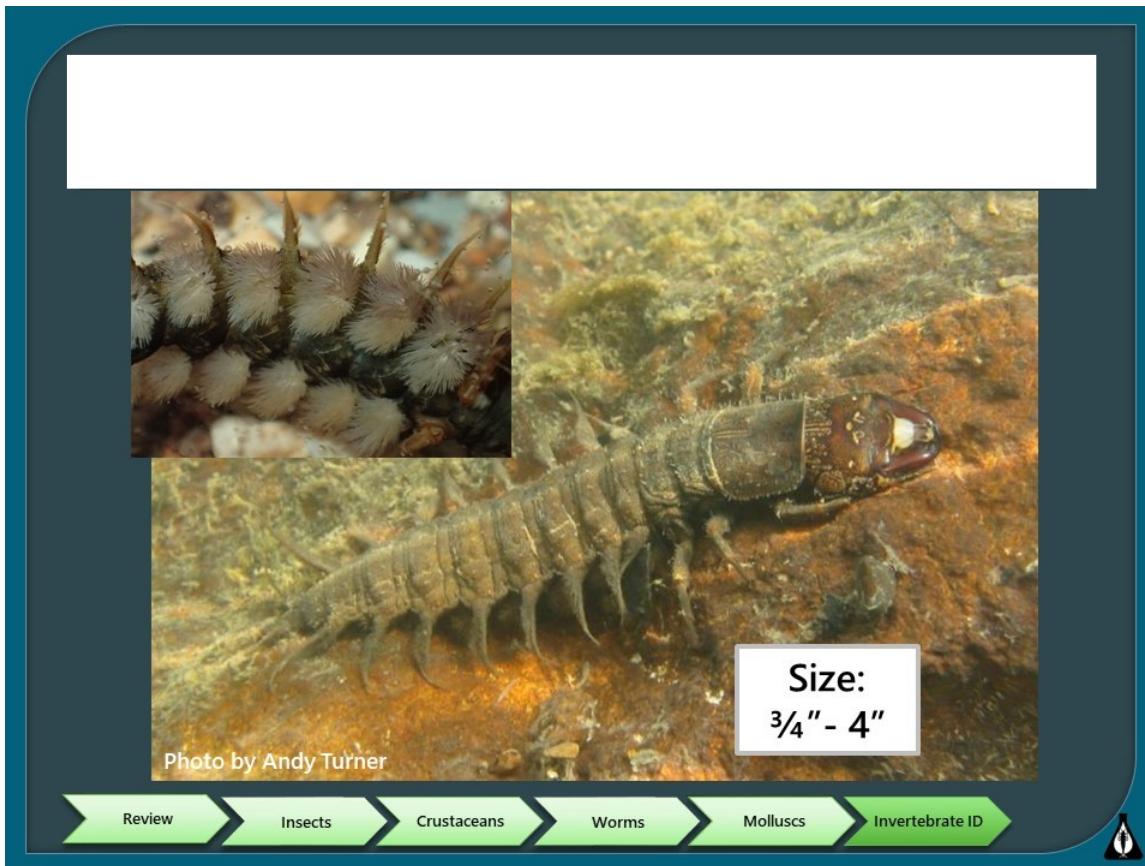
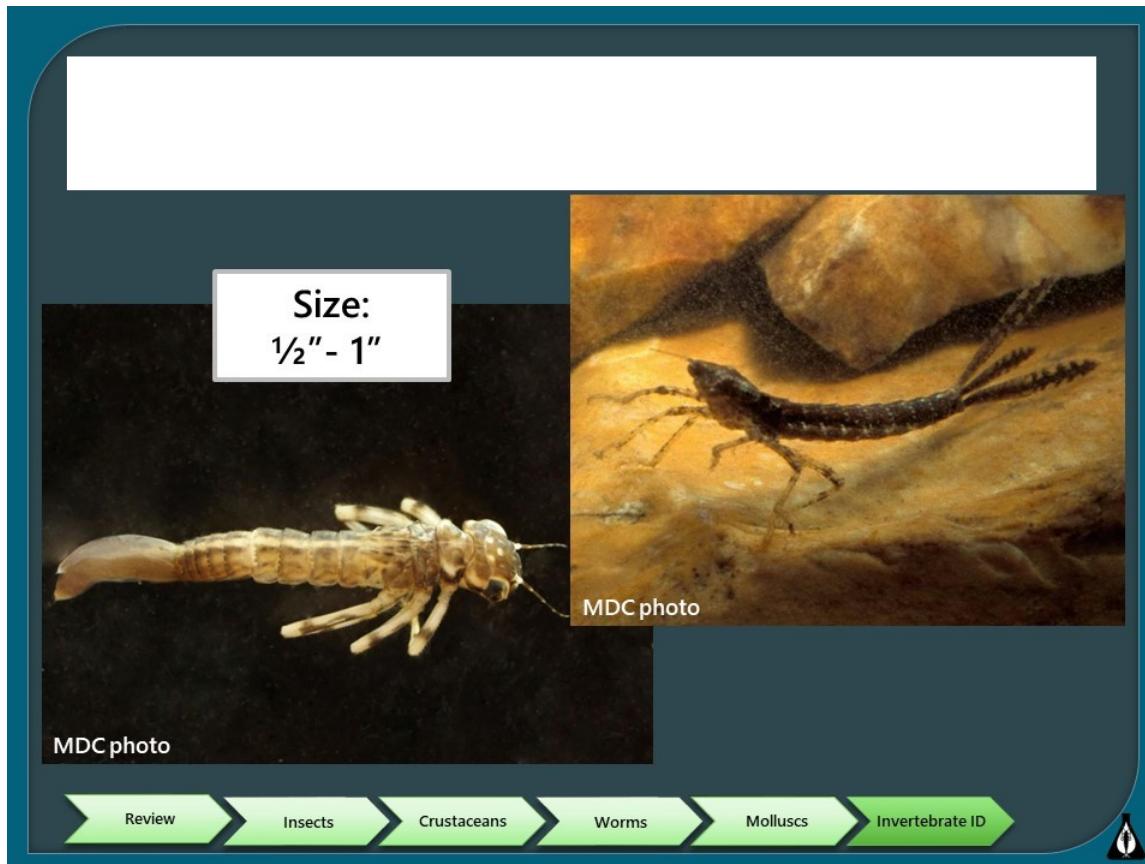


Photo by Andy Turner

Size:
3/4" - 4"

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



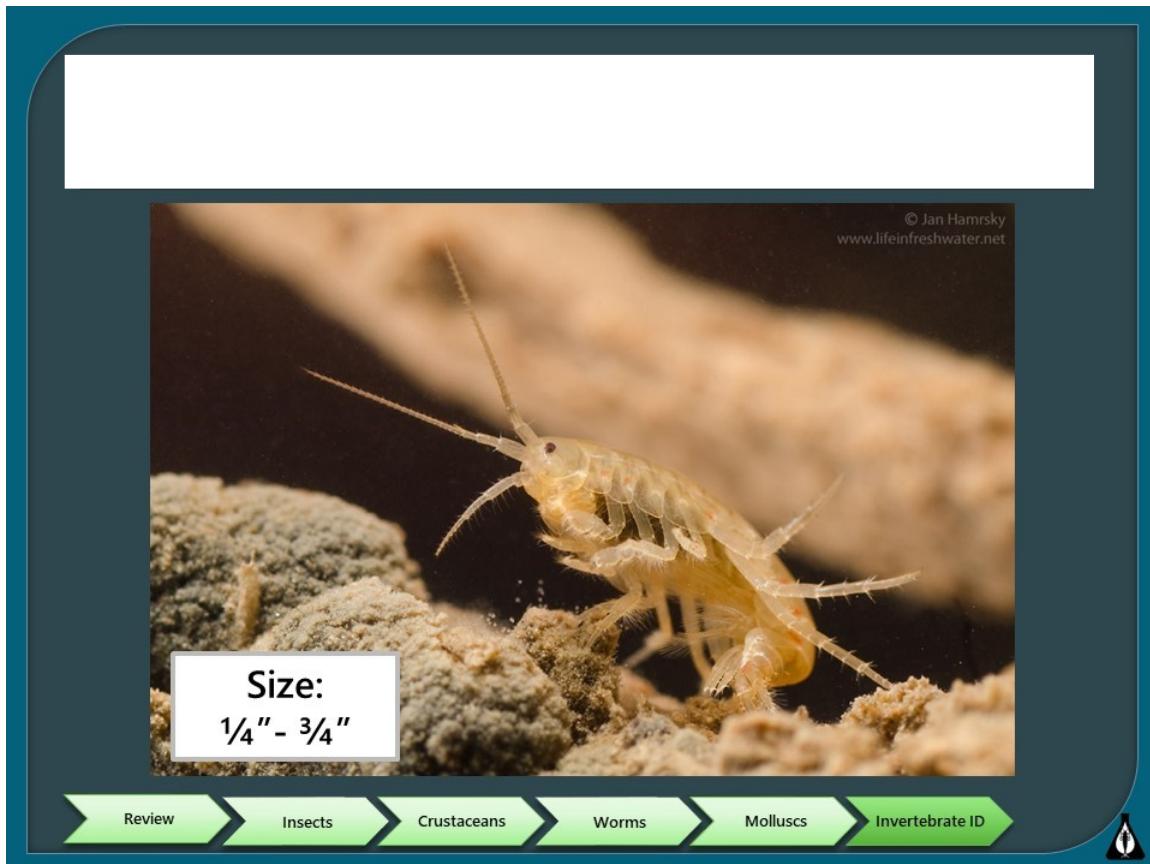
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1/2" - 1"

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Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

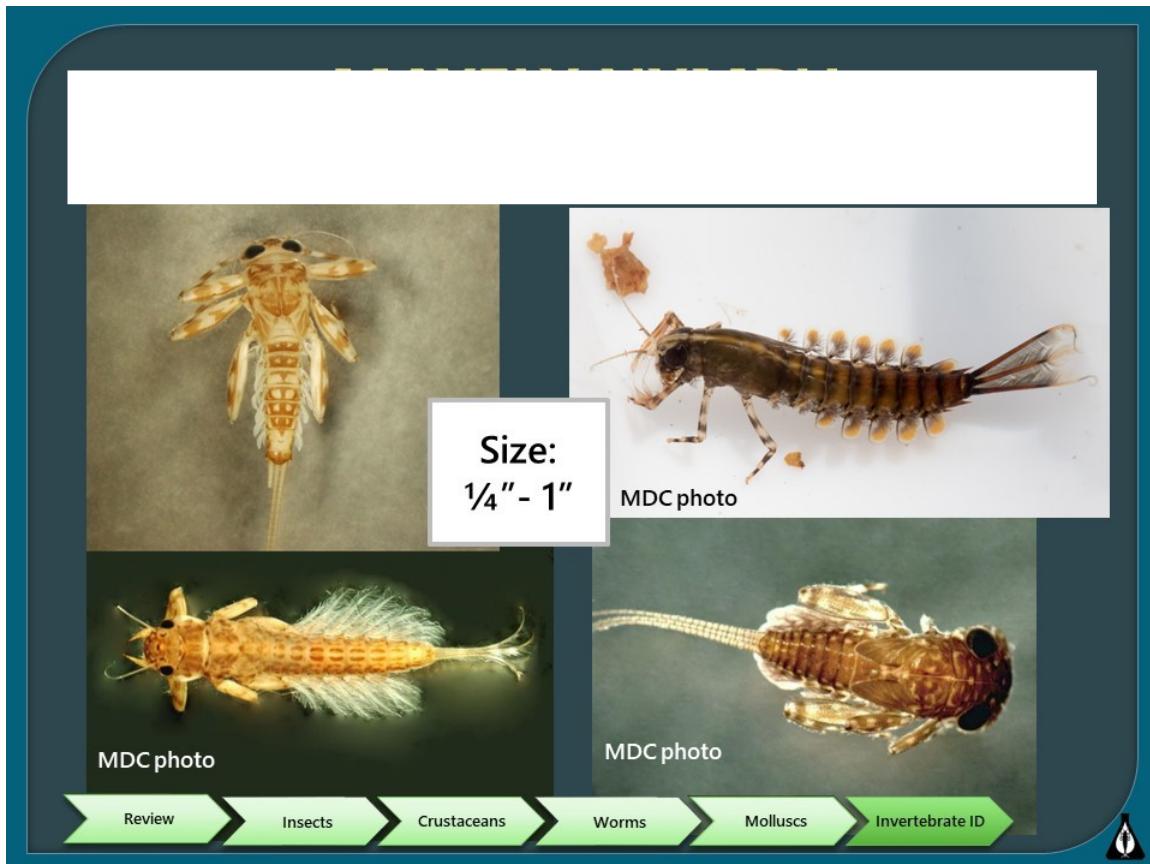
Invertebrate Identification



© Jan Hamrsky
www.lifeinfreshwater.net

Size:
1/4" - 3/4"

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID



Size:
1/4" - 1"

MDC photo

MDC photo

MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

Invertebrate Identification

Size:
1/16" and up

MDC photo

MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Size:
1/8" - 1 1/2"

DNR photo

MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Invertebrate Identification

Adult

Size:
1/16" – 3/8"

Review Insects Crustaceans Worms Molluscs Invertebrate ID

MDC photo **MDC photo** **MDC photo**

Size:
1/3" - 4"

Review Insects Crustaceans Worms Molluscs Invertebrate ID

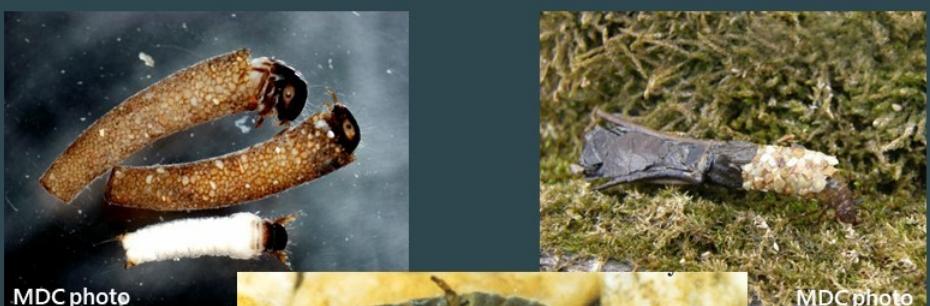
Invertebrate Identification



Size:
1/8" – 3/8"

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

This slide shows two brown and tan segmented worms against a black background. A text box in the upper left corner indicates the size range of 1/8" to 3/8". Below the image is a navigation bar with the following categories: Review, Insects, Crustaceans, Worms, Molluscs, and Invertebrate ID. The 'Worms' category is highlighted with a green arrow.



MDC photo



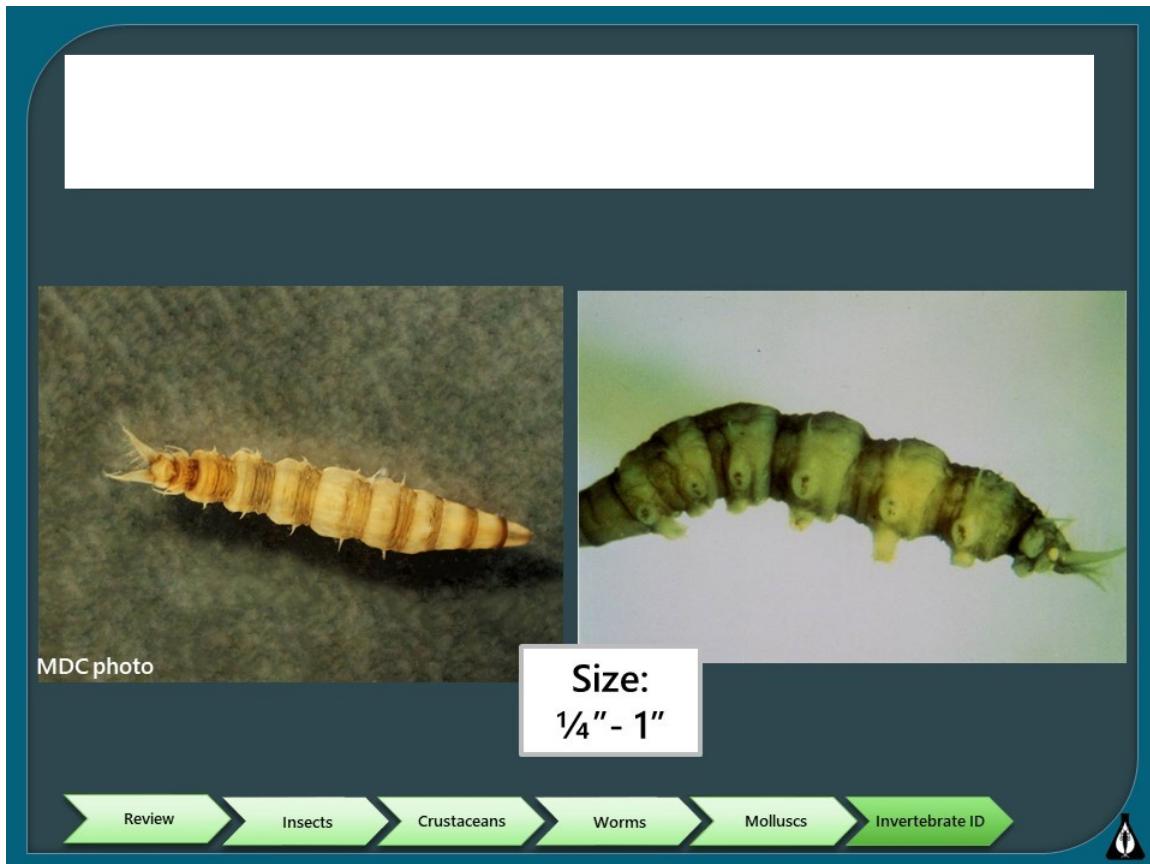
Size:
Up to 1"

MDC photo

Review > Insects > Crustaceans > Worms > Molluscs > Invertebrate ID

This slide displays three images of aquatic invertebrates. The top row shows a segmented worm and a small insect larva. The bottom row shows a larger brown larva. Each image is labeled 'MDC photo'. A text box in the lower left corner provides the size information: 'Up to 1"'. Below the images is a navigation bar with the following categories: Review, Insects, Crustaceans, Worms, Molluscs, and Invertebrate ID. The 'Worms' category is highlighted with a green arrow.

Invertebrate Identification

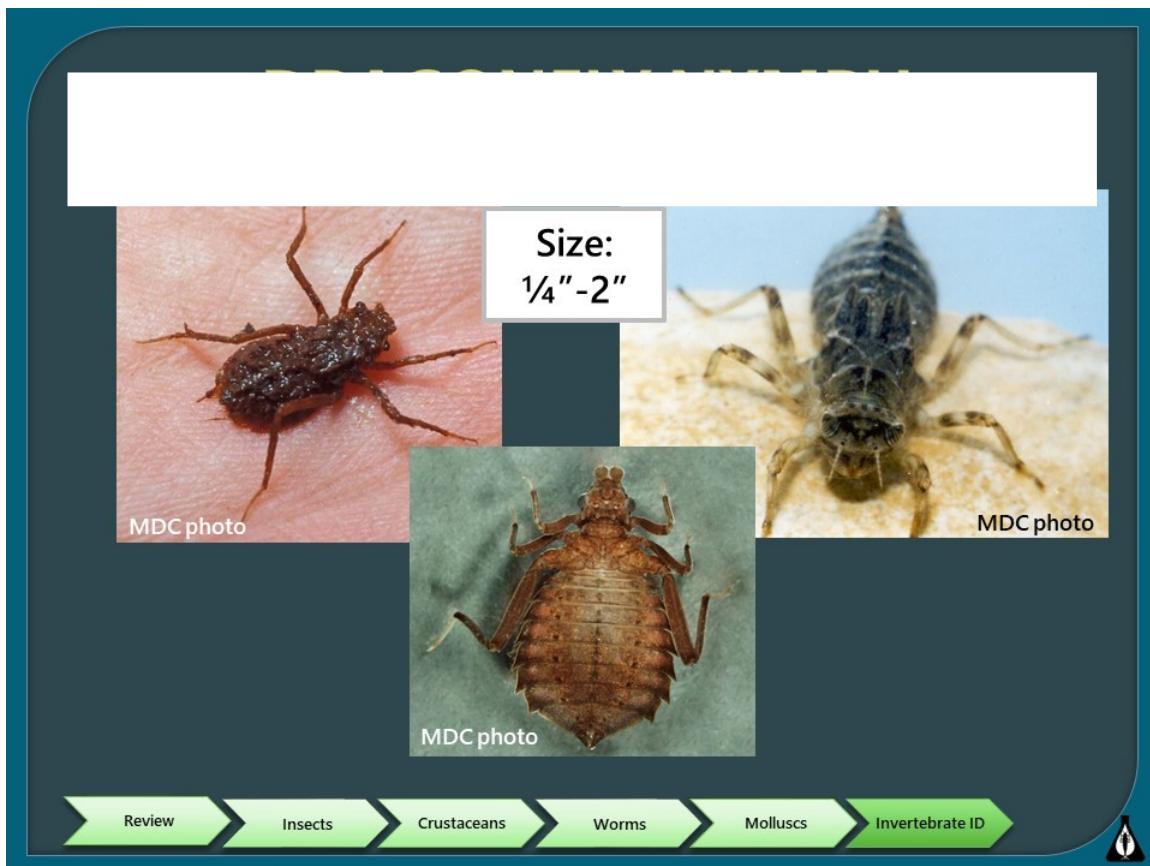


MDC photo

MDC photo

Size:
1/4" - 1"

Review Insects Crustaceans Worms Molluscs Invertebrate ID



MDC photo

MDC photo

MDC photo

Size:
1/4" - 2"

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Invertebrate Identification



MDC photo

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Size:
3/8"-1"

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID

Invertebrate Identification



MDC photo



MDC photo

Size:
1/16" and up

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



MDC photo

Size:
Up to 40"

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Invertebrate Identification



MDC photo

Size:
1/4"-2"

Review Insects Crustaceans Worms Molluscs Invertebrate ID



Size:
1/4"-1"

NABS photo

NABS (www.benthos.org)

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Invertebrate Identification



Size:
1/4"-1"

MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID



Size:
Less than 1/4"

MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Invertebrate Identification

Size:
Up to 1 1/2"

Photo by Tom Murray

Review Insects Crustaceans Worms Molluscs Invertebrate ID



Size:
1/4"-2"

MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Invertebrate Identification

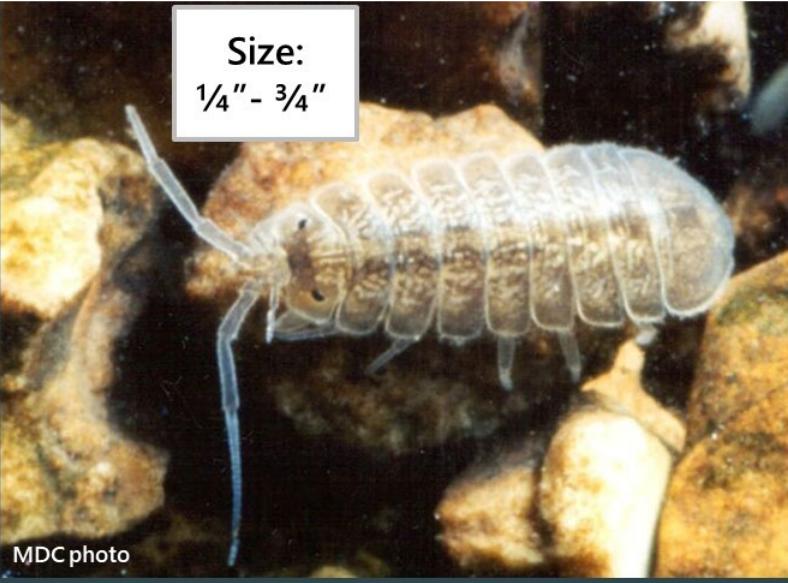


Size:
1/4"

DNR photo

DNR photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID



Size:
1/4" - 3/4"

MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Invertebrate Identification

Size:
1/16" and up



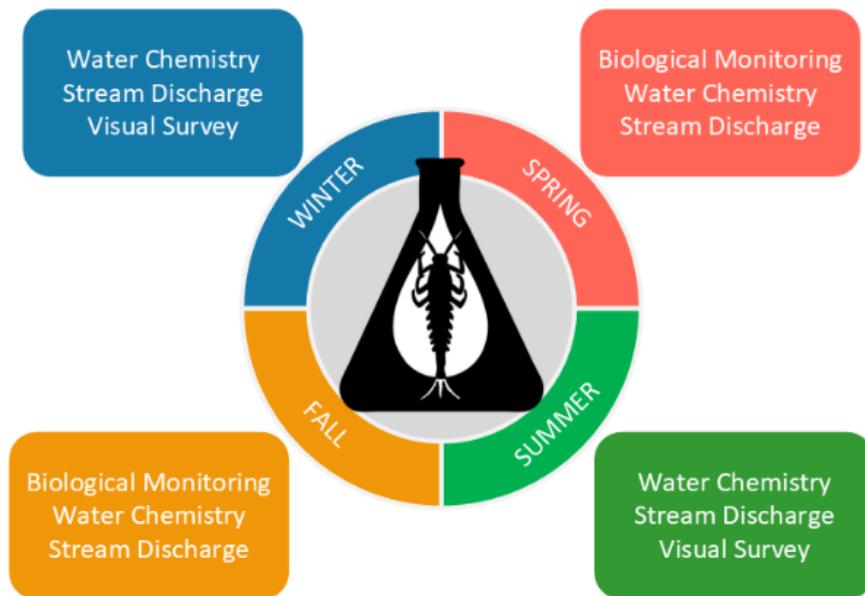
Review Insects Crustaceans Worms Molluscs Invertebrate ID



Size:
1/3"-2"

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Water Quality Monitoring Procedures



Volunteer Water Quality Monitoring Field Checklist

General supplies

Clipboard*

Litter bag*

Thermometer*

Appropriate footwear

Pencil

Stream Discharge

Stream Discharge Data Sheet*

Float balls*

100-foot measure tape*

Stopwatch

Two sticks or stakes

10-foot rope

Depth rod marked in tenths of a foot

Visual Survey

Visual Survey Data Sheet*

Biological Monitoring

Macroinvertebrate Data Sheet*

Hand lens or magnifier*

Kick net*

Forceps*

Two 1 1/8th inch diameter rod for sides of kick net

White ice cube trays for sorting

Squirt bottle

Chemical Monitoring

Water Chemistry Data Sheet*

Thermometer*

Transparency tube*

Dissolved oxygen kit*

Nitrate kit*

pH meter*

Conductivity meter*

*Program provided items

Items can be reordered at mostreamteam.org



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